AGRICULTURAL ENGINEERING

SEPTEMBER • 1950

A.S.A.E. Winter Meeting • Chicago, Ill., December 18-20

THE JOURNAL OF THE AMERICAN SOCIETY OF AGRICULTURAL ENGINEERS

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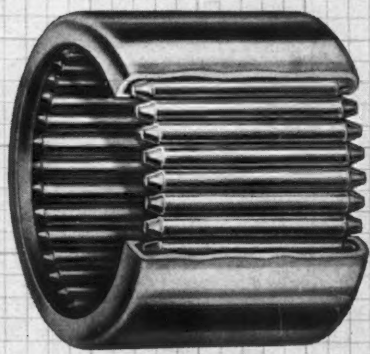

AGRICULTURAL ENGINEERING

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INDEX TO ADVERTISERS

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EDITORIAL

Rural Industries

PROGRESS in communications and in the transportation of people, power, and products is letting a lot of urban industry get out into rural areas for room to stretch, take a breath of fresh air, and kick up its production heels.

That makes it seem timely to distinguish between those industries which have moved to the country or rural towns simply to get away from the city, and those which are in the country to be close to agriculture.

We like to think of agriculture as the major rural industry, aided and abetted by several classes of related industries, both rural and urban. These include the industries which handle, process, and market the products of farms, the industries to which farm products are raw materials. They include the industries which produce equipment and materials for use in agriculture. And in the sense that industry includes all productive activities, they include business, trade, and professional services to farmers.

The same progress in communications, transportation, and other engineering, together with other factors favoring expansion of rural industry, are exerting an important influence on agriculture and the industries serving it. It can be expected to continue, and to influence the manner in which agricultural engineers can best serve agriculture. It will bear watching and considerable study.

To what extent will it help farmers to profitably carry their operations beyond basic husbandry of crops and livestock?

To what extent will it help farmers to improve their operating efficiency by carrying out preliminary or advanced processing of their products?

To what extent will it make it feasible for farmers to process raw materials for their own use, as, for example, in the compounding of fertilizers, insecticides, and mixed feeds, and the fabrication or modification of buildings and equipment?

What industrial products and services will be needed by agriculture, and to what extent can they best be provided by rural industries controlled by farmers or men who understand farmers?

What combinations of husbandry and related activities will enable farmers to produce most effectively and enjoy most fully the satisfactions of farm life and work?

What combinations of land, crops, livestock, structures, equipment, other capital, labor, management, operations, and operating methods will enable individual farms and related enterprises to succeed?

The increasing complexity of modern living, of products services, and methods available for use in production, and of our money economy, is increasing the complex of factors to be considered in setting up, operating, and keeping up to date any private enterprise, rural or urban. It is increasing the number, variety, and complexity of engineering problems involved in agricultural production and related industries.

This provides a growing opportunity for agricultural engineers to help farmers by considering and developing the industrial or production engineering inherent in the nature of modern farming and related rural industries.

Progress in Farm Processing

DESIRABLE emphasis on several points in connection with the further development of farm processing is provided, we believe, by W. M. Hurst in his paper entitled "Industrial Applications of Agricultural Engineering," published elsewhere in this issue.

It is important to recognize that processing operations, wherever performed, will be most efficient when guided by the principles commonly applied in industrial engineering.

It is important to recognize that farm processing is not a political or social movement, to be supported or opposed in general according to personal belief and interest. It is a matter of production economy in which the question of what processing should be done and where and by whom it should be done, should be decided on the merits of the individual case. Mr. Hurst has indicated many of the considerations to be studied.

Over a period of some twenty years or more, increasing numbers of agricultural engineers have come to recognize farm processing as a legitimate field of agricultural-engineering interest. A few have been directly employed in processing or in related research, and have become intensely interested in it. Most have been too preoccupied with immediate duties and responsibilities in other fields of agricultural-engineering activity to give more than passing notice to processing.

Quite a number of recent graduates in agricultural engineering have shown an interest in farm processing, but there has been relatively little opportunity for them to find actual engineering employment in this field, on which their interest might feed and grow.

Progress in farm processing, agricultural-engineering interest in the subject, and opportunities for actual employment in this field are interrelated and interdependent. Together they represent a considerable inertia to be overcome gradually before they can really get rolling. No one of these factors can get very far ahead of the other two.

This is the same situation encountered years ago in other fields of opportunity for agricultural engineering. It is far from hopeless. It presents a challenge.

Economic and engineering progress in any field gets under way first by someone recognizing an apparent new, unproven opportunity, and second by investment in developing and testing the opportunity in the hope that it will eventually pay out.

Farm processing needs more of the thinking in terms of what might be done which has given us the modern farm tractor, rural electrification, refrigerated farm storage, more efficient cotton ginning, the combine, the milling and meat-packing industries, alfalfa meal production, tung and other oil production, the modern fruit products industries, etc.

Theoretical opportunity for considerable increase in processing activities on farms and farm communities is now generally appreciated by leading farmers, other rural business men, agricultural engineers, agricultural economists, and various agricultural scientists.

The problem now is to find more new specific opportunities for farm-processing operations which offer apparent hope of paying off soon, with engineered equipment and operating methods now available. The refinements which normally follow further experience and study, supported and encouraged by success in capitalizing on these major opportunities, may make practical in the future some farm-processing operations which now would be marginal or unprofitable.

These present opportunities in farm processing are being recognized and developed by farmers, farm cooperatives and other rural business men to an extent which Mr. Hurst's paper helps us to realize.

Agricultural engineers in the U.S. Department of Agriculture, the college agricultural engineering departments, other public service agencies, and private employment are investing time and talent, as well as public and private funds, in developing and testing these opportunities. They are helping to show the extent to which farm processing involves agricultural applications of industrial-engineering principles.

Professional consideration within the American Society of Agricultural Engineers, of farm processing as a field of service for agricultural engineers, helps to clarify the opportunities awaiting development, the challenges which agricultural engineers can find in it; the problems they may enjoy the satisfaction of solving. Mr. Hurst's paper provides a sound foundation for further individual and group study of these points.

Under these influences we can look for continued progress in the nature of a gradual evolution toward increased quantity and variety of farm processing on an economically sound basis; rather than a revolution in farming for the sake of seeing the processing wheels go around.

AGRICULTURAL ENGINEERING

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Industrial Applications of Agricultural Engineering

By W. M. Hurst
MEMBER A.S.A.E.

FARMERS as individuals, as stock companies, and as farmers' cooperatives have for a long time attempted to increase their incomes by conditioning or processing agricultural products for market or by processing or manufacturing supplies for farm use. Activities involved in such enterprises are generally referred to as processing. However, processing as such does not cover the entire field.

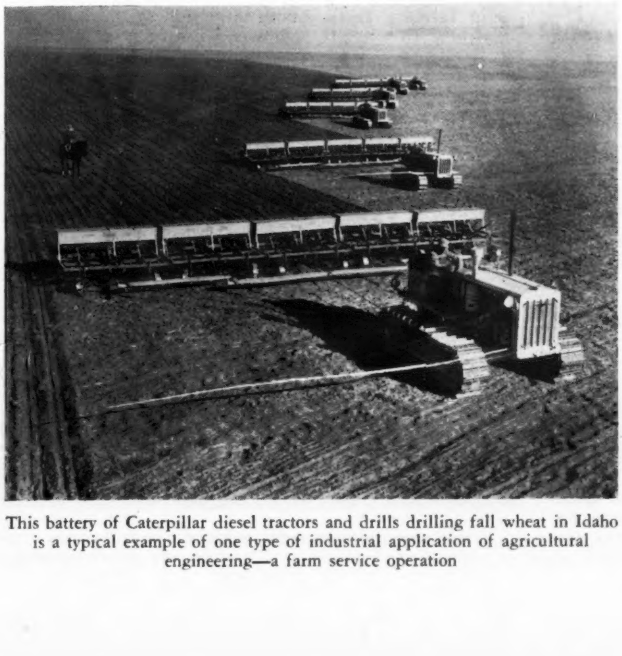
The desirability and feasibility of processing or conditioning raw products on or near the farm by farmers, individually or collectively, or by private interests depends in part upon the product, availability of facilities, and the complexity of the enterprise. Before taking definite steps in establishing a plant, information should be obtained on (a) market outlets, (b) supply of raw material, (c) nature of operations, (d) equipment needs, (e) plant design, size, and location, (f) investment, (g) working capital, (h) applicable local, state, and federal laws, (i) labor requirements and availability, (j) transportation, (k) public utilities, and (l) quality control.

The availability of electric power throughout the country, machinery development, and the needs for some decentralization of industry have resulted in the construction and operation of many plants in rural areas. Also, increases and shifts in population in some parts of the country have been responsible for new plants. Often small rural plants are the beginning of large factories. However, small plants in some categories have as high or higher unit production per worker than those in the large production-line class. Problems of an engineering nature are numerous in all such instances, and agricultural engineers have received their share of requests for information needed in designing, building, equipping, and operating the plants.

As a general rule, agricultural engineers in the state and federal research agencies have confined their activities to problems associated directly with the farm, farmstead, and farm home. Some exceptions have been the work done by agricultural engineers, especially during the war, in processing hemp and flax and in the processing and preservation of feeds and foods. We have had and continue to have plenty of jobs to do on and around the farm. However, since the profession is dedicated to the service of agriculture, and farmers have a big stake in rural industries, we should not neglect activities in this field.

This paper was prepared expressly for AGRICULTURAL ENGINEERING.

The author: W. M. HURST, senior agricultural engineer, division of mechanical processing of farm products (BPISAE), U.S. Department of Agriculture, Washington, D.C.



This battery of Caterpillar diesel tractors and drills drilling fall wheat in Idaho is a typical example of one type of industrial application of agricultural engineering—a farm service operation

The 1948-49 annual report of the Farm Credit Administration (USDA) shows 10,135 farmers' cooperative marketing and purchasing associations operating in the United States during the 1947-48 season. While not all of these associations processed farm products or supplies for farm use, many of them did. There are also many individuals and companies engaged in this type of business located in small town and rural communities.

The American Society of Agricultural Engineers has no subject-matter division devoted generally to industrial engineering for agriculture. Agricultural engineering departments at several state colleges have a section for processing in addition to their farm machinery, farm structures, rural electrification, and soil and water conservation work.

The activities of the Division of Mechanical Processing of Farm Products (BPISAE) of the U.S. Department of Agriculture began with the establishment of the USDA Cotton Ginning Laboratory in 1930. During World War II, special attention was given to dehydration of foods and compressed packaging. Projects now include, in addition to cotton ginning, work on fiber flax processing in cooperation with the Oregon Agricultural Experiment Station; production and processing of tropical and semi-tropical fibers such as sansevieria, ramie, and kenaf with the Florida Agricultural Experiment Station; rural industries and services, University of Georgia; fruit and vegetable processing and handling, Michigan Agricultural Experiment Station; poultry processing, New Jersey Agricultural Experiment Station; and farmers' cooperative processing plants and operations, Farm Credit Administration. Part of the cotton-ginning work and the cooperative projects with Georgia, Michigan and New Jersey are financed under the Research and Marketing Act of 1946. All of these projects deal with machinery and facility developments of a technical nature, except the cooperative project with the FCA, in which emphasis is placed on plant design, layout and equipment for greater efficiency both from the standpoint of quality and quantity of production. These investigations are generally of the survey type but may include applications of new and improved equipment or techniques. Studies of the survey type have included farm and small commercial poultry-dressing plants, regular production-line poultry-dressing plants, farmers' produce markets, livestock feed manufacturing, and cheddar cheese plants. They have been regional or national in scope.

The number and types of activities under agricultural or rural industries cover a wide field and several attempts have been made to define or encompass the scope of activities.

Hurd* gave the following definition: "A rural industry is an activity in which the predominant man power resides on the farm, and where modern technology is applied to fabricate, process, or otherwise transform products into a more finished state."

The ASAE Committee on Agricultural Industries prepared a definition which was used in part by White†, viz., "From an engineering viewpoint, agricultural industries and services may be defined as any enterprises where engineering techniques are applied in preserving or changing the form of agricultural products; in assembling, preparing, packaging, marketing, and transporting agricultural products, and in processing or manufacturing materials and supplies for farm use."

Chapman‡ referred to this new and broad field for agricultural engineers as "agricultural industries and services," and stated that agricultural engineers "... are involved in determining the scope of applications that are to be embraced in this branch of the engineering profession."

The nature of farming is such that industrial engineering for agriculture covers activities which can be grouped under at least five major headings or categories. These include farm supplies, farm services, marketing service and facilities, crop conditioning and storage, and crop and livestock products processing. Some enterprises listed under the several categories are of minor importance and others are not generally thought of in connection with the work of agricultural engineers. However, they all contain some engineering application, such as heating, ventilating, drying, freezing, refrigeration, air conditioning, conveying and handling, reducing, separating, mixing, blending, weighing, measuring, forming, extruding, pressing, power application, and controls.

Farm Service and Supply Plants: greenhouses, nurseries, hatcheries, rendering plants, feed grinding and mixing, fertilizer mixing, insecticide and fungicide preparation, fence post treating, boxes and baskets, cooperages, tool handles, brooms, and ice.

Plants in this group grow, fabricate, process, or manufacture farm supplies and are found in rural areas. Some, such as those for fertilizer, feed, and insecticides, are often commercial in nature and not necessarily located in production areas. However, there are many small ones. Agricultural engineers are probably more familiar with equipment and operations in poultry and livestock feed manufacturing plants than in the other enterprises listed.

Farm Service Operations: spraying, dusting, fumigating, painting, repairing, and servicing machinery, repairing and servicing appliances, contracting farm work, providing and servicing utilities, and building and repairing buildings.

These service operations are performed by engineers and others working from towns and villages in farming areas. They provide agriculture and the farm home with services similar to those available to urban dwellers.

There is reported a need for qualified rural builders and for prefabricated structures such as septic tanks. More farm water cisterns for fire control are needed.

Marketing Services and Facilities: sales barns, warehouses, roadside markets, farmers' retail and wholesale markets, and auctions.

*C. J. Hurd, formerly chief, agricultural engineering development division, Tennessee Valley Authority, in a paper presented at the ASAE annual meeting, June 20, 1944.

†Harold D. White, research professor of agricultural engineering, University of Georgia, in a paper presented at a meeting of the Southeast Section of ASAE, February 14, 1948.

‡Dr. Paul W. Chapman, dean of agriculture, University of Georgia, in a paper presented at the ASAE annual meeting, June 25, 1946.

Engineering problems encountered in marketing centers usually have to do with location, building design, traffic, drainage, arrangement of facilities, approaches, refrigeration, lighting, and sanitation. At large markets a number of packaging, grading, and processing services may be provided.

Improvements in transportation equipment would reduce deterioration in quality and losses occurring in shipping fresh fruits and vegetables. Better loading, shipping, unloading and handling facilities for livestock should be developed to reduce losses associated with bodily injury and improve labor efficiency.

Crop Conditioning and Storage: packing fresh fruits and vegetables, drying, curing meat, curing cheese, curing root crops, cold storage, seed cleaning and treating, grain elevators, compresses, wool grading and scouring, and warehousing.

Grain and forage drying and root crop storage probably have received more attention by agricultural engineers than any other items listed under crop conditioning and storage. The packing of fresh fruits and vegetables, seed cleaning and treating and grain elevators are active projects in some areas.

Processing Foods: canneries, freezing plants, frozen food locker plants, dehydrators, abattoirs, creameries and dairy products, poultry dressing, eggs and egg products, corn meal and grits, syrup, starch, nuts, oils, juices, pickles, vinegar, jelly and jam, condiments, confections, apple butter, peanut butter, honey, meat by-products, beverages, and cordials.

The food-processing list is the largest and perhaps also the most important so far as agricultural engineers are concerned. There are both small and large operators and the industry has many ramifications. A variety of technically trained people are employed, including food technologists, bacteriologists, home economists, commodity specialists and agricultural, chemical, and mechanical engineers. Quality control is important and often must be extended to include cultural practices and marketing phases.

Sanitation is one of the major problems in operating most food-processing plants. There are federal, state, county and municipal regulations dealing with working conditions as well as product sanitation in many instances. To keep a food-processing plant clean is a never-ending and time-consuming job even under the best of conditions. Design features are very important as aids in sanitation; these include layout, lighting, drains, floor slope to drains, finish for floors and walls, water supply, and waste disposal.

The food-processing industry is faced with many machinery development or adaptation problems, especially for small-scale operations. Improvements in labor efficiency through methods engineering are most important.

Mechanical refrigeration has had a profound influence in shaping the food-processing industry during recent years for both large and small plants and in (Continued on page 444)

Farm conservation contracting represents one of the many opportunities open to agricultural engineers for self-employment

Mechanization of Southeast Agriculture

By George B. Nutt
MEMBER A.S.A.E.

THE states of the Southeast—Virginia, North Carolina, South Carolina, Georgia, Florida, Alabama, Tennessee, and Mississippi are in the news today from the agricultural and industrial viewpoints. Industrial development and farm mechanization are complementary programs and will be considered together in this discussion. Natural resources consisting of a good climate, raw materials, fuel, adequate electric power and stable labor have attracted the attention of many manufacturers to the Southeast. An impressive record of industrial progress has been made since 1939. The 1947 census of manufacturers for the period 1939-47 gave the Southeast an increase of 248 per cent "on value added by manufacturers" against the national average of 204 per cent. South Carolina, Mississippi, Georgia, and Alabama were outstanding in this achievement with South Carolina ranking second in the nation. Contributing to this industrialization were manufacturing gains in textiles, lumber and products, chemicals, ceramics, furniture, farm machinery and tobacco.

Farming has undergone some changes during this period. Beginning about 1935, farmers became more conscious of soil and water conservation. Farming practices have changed as a result of the conservation program and changing economic conditions. The new and improved farming practices combined with the industrial development have given the Southeast an infectious air of progress.

In this connection, let us look at the Southeast as a consumer market. Joseph K. Heyman, southeastern business consultant, reports: "Retail outlets rang up total sales of more than 16 billion dollars in 1948; the total was 4½ billion in 1939, the last census year.

"The Southeast enjoyed a sales gain of 252 per cent between the two census counts. This is substantially better than the 210 per cent gain for the United States as a whole. Every state in the region beat the national gain. This is further evidence that Dixie is on the rise."

The U. S. Department of Commerce gives an optimistic report for the Southeast using new construction figures as a yardstick. Urban construction was up 11 per cent over 1948 during the first 11 months of 1949 compared to a nationwide gain of 4 per cent. Alabama, Mississippi, and South Carolina led the region with gains of 30, 26 and 23 per cent, respectively.

The industrial progress of the Southeast with its growing markets is materially affecting the agriculture of the area. Farmers of the Southeast, to a great extent, have been dependent upon cotton. I do not want to minimize the importance of this crop which is the main source of farm income to several of the states. However, the shrinking market for cotton combined with higher yields per acre has released many acres for other uses. We are discovering that soils of the Southeast may be utilized for a wide variety of crops. Here are the figures for 1948 in terms of acres: Cotton, 8,184,000; corn, 16,035,000; small grain, 5,521,000; tobacco, 1,031,100; peanuts, 2,977,000; soybeans, 1,691,000; hay, 8,044,000. In addition to these major crops, many thousands of acres are utilized to produce fruit, truck crops, pecans, and miscellaneous commodities.

Only in recent years have farmers discovered that adequate grazing may be provided for livestock throughout the year. Thousands of acres which once produced cotton and more recently were idle are now covered with a blanket of grass and legumes. Some states have adopted the slogan "Cover the state with a blanket of green," and those blankets which are grazed by high-grade cattle are strikingly beautiful during the winter months when much of the nation is under a blanket of ice and snow.

The buying power of the Southeast, mentioned previously, is largely responsible for the livestock program and the crops which are being produced for livestock feed. There is a market for fresh meat, milk, and other products that did not exist at one time. Southeastern states have been importing milk, but the trend is toward developing a dairy industry to meet the needs of the region. Agricultural Commissioner L. Y. Ballentine of North Carolina reports that his state imported nearly 79 million pounds of fluid milk in 1948. Last year the amount brought in from other states dropped to 53 million pounds. Now, he says, North Carolina is importing no fluid milk for the first time in 10 years. In this livestock program, the Yankees are joining us. Farmers, particularly dairymen from the Midwest, are going into the dairy business right in our midst. We welcome these migrants because they are bringing the know-how with them.

Progress in Mechanization. What does the industrial development and changing pattern of agriculture mean in terms of mechanizing agriculture? Let's look at some sales figures for two prominent lines of farm machinery. A company sales branch serving two states sold $2,432,084 worth of tractors and machinery in 1938, as compared with $12,252,620 in 1949. Sales increased during this entire period with the exception of 1943 and 1944 when production of farm machinery was curtailed in favor of munitions. Another company branch comprising approximately five states of the Southeast had a total sales volume of $1,000,000 in 1938. The combined sales during 1948, 1949 and 1950 totaled $60,000,000 by May of this year and the sales territory has not been altered. The volume in 1948 increased 50 per cent over 1947, and the 1949 volume increased 40 per cent over the previous year in spite of a very poor crop year. Indications point to 1950 surpassing all other years in volume of business for this company.

What about other companies? Sales figures are not available, but it is significant that within the past year five companies have provided new branch facilities in the area serving the Carolinas, Georgia, Alabama, and Florida. Some of these are new quarters for well-established lines, while others are factory branches replacing jobbers. All of these companies set new sales records in 1948 and 1949 and hope to repeat this achievement in 1950.

The increase in the number of tractors on farms is an index of the trend toward mechanizing Southeast agriculture. The following comparisons are based on the 1940 census and the estimate made by *Farm Implement News* as of July 1, 1949:

States	1940	1949	Increase, per cent
Mississippi	10,577	40,504	233
Alabama	4,129	33,510	711
Georgia	9,327	49,060	426
South Carolina	4,791	26,850	460
North Carolina	12,756	52,130	308
Virginia	11,951	43,650	265
Florida	7,703	25,660	233
Tennessee	11,817	39,235	232
Total	73,051	310,599	325

E. D. Wilbourn of *Farm Implement News* says, "I doubt that any other section of the country would equal the Southeast in the percentage increase of tractors on farm during this 9½-year period."

During this same period, the mule population has been declining rapidly. The average mule population during the period 1938-47 for the eight states was 1,799,000. In 1949, the

This paper was presented at the annual meeting of the American Society of Agricultural Engineers at Washington, D. C., June, 1950, as a contribution of the Power and Machinery Division.

The author: GEORGE B. NUTT is head, agricultural engineering department, Clemson College, Clemson, S. C.

number had dropped to 1,482,000. The statement has been heard that "in two or three decades, the mule will be such a rare animal that a visit to the zoo will be necessary to see one." I do not think this reliable old hybrid is headed for extinction, but he is rapidly being replaced by more satisfactory sources of farm power.

The postwar industrial expansion of the Southeast and the mechanization of agriculture of the region were timed properly. The Southeast lagged behind other sections of the United States in agricultural mechanization for two important reasons. First, there was an oversupply of cheap farm labor because competition for labor was negligible. Second, crops typical of the area such as cotton, tobacco, peanuts, and sweet potatoes were difficult to mechanize completely. These crops, as they have been grown for generations, are great consumers of hand labor.

The man-hour requirement for producing these crops has challenged agricultural engineers of the farm implement industry and experiment stations and great progress has been made in reducing the labor requirement. Cotton, for example which requires approximately 150 man-hours per acre by the time-honored system of mule-drawn implements, hand hoeing and harvesting, has been reduced to 18 hours or less with tractors, mechanical harvesters, etc. There is still much to be accomplished in weed and grass control and development of mechanical harvesters suited to small farms of the Southeast before complete mechanization of cotton production may be considered practical. Similar conditions prevail for many other typically southern crops. Very little progress has been made in reducing the man-labor requirement in producing flue-cured tobacco. Agricultural engineers met with the tobacco workers in a conference held at Gainesville, Florida, for the first time this year. With an agricultural engineering section added to the tobacco workers' organization, it is to be expected that further efforts will be made to substitute machinery for many of the hand operations required in producing tobacco.

GREATER PROGRESS IN MECHANIZING CERTAIN CROPS

Much greater progress has been made in mechanizing the production of corn, small grain, soybeans, and hay. Machinery for these crops was developed for other sections and modified where necessary to meet the peculiar requirements of the Southeast. Although the Southeast is thought of as a cotton area, it is interesting to note that more than three times as many acres are utilized to produce feed crops. There are two acres of corn for each acre of cotton. Admittedly, the corn yields are low, but the use of hybrid varieties adapted to the area, increased fertilization and better cultural methods, is bringing about a yearly increase in corn yields. What does this means in terms of mechanization and economy to the region? Any livestock program is dependent upon feed produced at a minimum cost. With the exception of corn, feed production is fairly well mechanized in the Southeast. The latter will be mechanized to a greater extent as varieties suited to harvest with mechanical pickers become more common. The feed and livestock program also means that we are not wholly dependent upon cotton.

Considerations of the Future. In 1945, there were 1,616,592 farms in the 8 southeastern states. Assuming some increase in the 310,599 tractors on southeastern farms for 1949, reported by *Farm Implement News,* there is approximately one tractor for every 5 farms. Obviously, there is a discrepancy in this line of reasoning because many farms use more than one tractor and the census classifies some holdings as farms that are too small to warrant a tractor. The fact remains that the market potential for tractors and implements is great in the Southeast. Combined with the opportunity for sales is the responsibility to develop machinery suited to the peculiar needs of the region. Implement companies have done much in this respect, but many farmers are still struggling with equipment not adaptable to their particular needs. Typical southern crops such as cotton, peanuts, and tobacco await the further development of machines to lower production costs.

There is a great industrial and agricultural awakening in the Southeast. The better balance between agriculture and industry is bringing general prosperity to the region.

Agricultural Industries

(Continued from page 442)

transporting perishables. Home freezers and freezer locker plants have brought the practice of freezing as a means of preserving food to the home and rural communities. Locker plants have a preponderance of rural patrons. Attractive consumer packages, refrigerated display cases and zero storage facilities have been contributing factors in the widespread distribution of frozen foods for the urban population.

Frozen food locker plants have brought about some decentralization of the meat-packing industry. These plants usually provide chilling, aging and meat-processing services for their patrons. Some have abattoirs for the benefit of patrons and also butcher for the public. In most such instances meat is prepared only for local consumption. Federal meat inspection is required for the product in interstate and foreign commerce. The processing of poultry has proved to be a profitable operation in some instances.

Product sterilization and atmospheric control are major engineering problems in some food-processing procedures. Low-pressure vacuums are important adjuncts to some dehydration, concentration and sterilization procedures. Electronic applications of the electric eye, color grader, ultrasonic and high-frequency radiation are being developed for various purposes by agricultural engineers.

RESEARCH ACTIVITY IN FOOD PROCESSING

At some state colleges practically all research activities on food processing are concentrated in a food technology department. At others the subject-matter groups concerned with the product, such as horticulture, animal industry and dairy industry, work in their respective fields. In the USDA, research work on the technical phases of food processing are carried on by several bureaus under the Agricultural Research Administration. To an increasing extent agricultural engineers are being included as cooperators.

Processing Fibers: cotton gins, flax mills, hemp mills, and decorticating plants.

Vegetable fibers and wool doubtless will continue to have stiff competition from artificial fibers. Problems of an engineering nature for vegetable fibers deal principally with mechanization in harvesting and processing for reducing costs and maintaining quality. In working with vegetable-fiber crops an increase in unit production per worker is often made at the expense of quality. The introduction of mechanical cotton strippers and pickers is producing more engineering problems at the gin. The mechanical harvester shortens the ginning season and complicates the cleaning problems. Cotton ginning is a seasonal operation at best and the plants are idle from 8 to 9 months each year. There might be a possibility of synchronizing cotton ginning and cottonseed oil milling for orderly year-round ginning. The major problem in this connection involves the conditioning and storage of seed cotton.

Processing Structures: saw mills, planer mills, cement and other building block plants.

In some areas timber has gone through the industrial phase and is back to a farm or community basis. In most instances agricultural engineers are more interested in the use of lumber than in its preparation, but in the farm or community saw and planer mills there are many problems with which agricultural engineers can be of service.

The production of building materials such as cement and other blocks should perhaps receive more attention by agricultural engineers. There is a need for better engineering control of the production machines used for molding concrete block and silo staves. There are also problems associated with the collection, fabrication and use of waste products.

In the research, operation, and servicing of these industrial engineering applications to agriculture there are numerous job opportunities for agricultural engineers. Many of these opportunities are for self-employment in operation or as consulting engineers. Much of the development work in the field, however, must first be accomplished by research programs carried out by agricultural engineers in public service.

Mechanization Aids Conservation Practices

By John R. Carreker
MEMBER A.S.A.E.

THE use of mechanized equipment and the adoption of tested conservation cropping methods is developing in the Southeast a more productive and more stable type of agriculture.

Conservation was described by Ordway(6)* as "The planned management and wise use of nature's resources—as a whole, as well as severally. It aims, in cooperation with science and nature, to increase their quality, quantity and availability through the years.

"The science of conservation seeks, through knowledge of environmental conditions and development of new techniques, to increase production and productivity, decrease waste and assure continuing supply.

"Economically, conservation seeks to attain maximum yields of top quality continuously."

Dr. H. H. Bennett has said, "Use of each acre according to its capabilities and treatment according to its needs are the basis of soil and water conservation farming."(1)

We have now, through mechanization of farming in the Southeast, the tools for applying conservation practices widely in our farming procedures. In keeping with the above-mentioned descriptions, these conservation practices imply the full use of agricultural land in continuous profitable production.

Progress in Mechanization. Mechanization of farms in the Southeast has progressed very rapidly in recent years. The demand for tractors, plows, planting and cultivating equipment, broadcast fertilizer distributors, grain drills, combines, and other machines skyrocketed during the war period. There has apparently been no tendency to return to farming with mule-drawn equipment since the war.

As an example of the mechanization that has taken place in the Southeast, the upward trend in the number of tractors and the downward trend in the number of horses and mules on farms in Georgia are shown in Fig. 1. The 50,000 tractors in 1950 represent about one tractor for each five farms in the state.

Comparative data for a number of other implements on farms in Georgia† show similar increases, as follows:

	1942	1945	1949
Combines		3629	6600
Corn pickers	40	75	600
Tractor mowers			10,000
Side-delivery rakes	1,000		6,000

Much work has recently been done on farms with heavy machinery. Farm ponds and reservoirs, numbering into the thousands, have been built. Land clearing, reshaping of fields, building terraces and constructing drainage systems have all been popular uses of large equipment. While all of these jobs form a part of an over-all soil and water conservation program, in the long run the major concept of this program deals with how crops are produced. This paper, therefore, discusses primarily mechanization in connection with cropping practices in the Southeast.

Row-cropping has characterized Southeast agriculture since the beginning of farming in this area. The trend toward mechanization today is closely tied with the continued production of these same row crops of cotton, corn, peanuts, etc. The rapid expansion in the number of tractors and allied machines so far has largely been to replace mules, and to offset labor shortages.

Even so, some significant changes in cropping have been made. Excerpts quoted below from the annual report of the chief of the Soil Conservation Service (1, 2, 3) in 1945, 1946, and 1949 show some of these trends.

In 1945, Dr. H. H. Bennett stated, "Continued success has been had in getting cover crops grown on croplands. In the principal peanut-growing areas of Georgia, Florida, and Alabama, for example, 236,956 acres of peanut land was seeded to winter legumes. . . . . Increased popularity of blue lupine has been particularly striking — from 2,146,460 lb of seed planted in these three states in 1943 to 8,449,530 lb in 1944. All of this seed was harvested in the states where it was planted" (page 17).

We quote from the 1946 report (page 19): "In the Southeast the 1946 harvest of blue lupine seed was over 37,000,000 lb. . . . . The production of wild winter peas (*Lathyrus hirsutus*) has expanded very rapidly in Mississippi and Alabama."

In 1949 (page 29), Dr. Bennett wrote: "The tall fescues—Suiter's grass (Kentucky 31 fescue) and Alta fescue — have continued to show outstanding values for conservation seedings. The total estimated acreage planted to these two fescues in the southeastern region is over 300,000. . . . . The seed harvest of these two fescues in the southeastern region alone, will amount to more than 10,000,000 lb."

Dr. Harry L. Brown, dean and director, college of agriculture, University of Georgia, in a speech before the Georgia Farm Bureau Federation at Atlanta, November 8, 1949, stated: "In 1930, Georgia farmers seeded 87,500 acres to winter legumes. By last year, this acreage grew to 910,150. . . . . Since 1940, the acreage devoted to summer legumes has increased from 648,000 to 1,339,000. The acreage devoted to improved pastures now totals 2,400,000 which is approximately 1,000,000 acres above that of 1924. During last year, Georgia farmers seeded approximately 400,000 acres to improved permanent pasture. Acreages devoted to oats and wheat have grown from 322,000 in 1924 to 749,000 in 1948.

This paper was presented at the annual meeting of the American Society of Agricultural Engineers at Washington, D. C., June, 1950, as a contribution of the Power and Machinery Division. A report of research conducted by the Southern Piedmont Conservation Experiment Section, Soil Conservation Service (Research) USDA, in cooperation with the Georgia Agricultural Experiment Station.

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*Numbers in parentheses refer to the appended bibliography

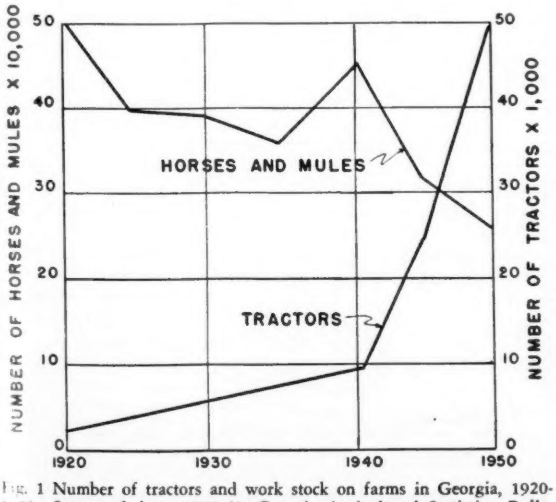

Fig. 1 Number of tractors and work stock on farms in Georgia, 1920-1950. Source of data: 1920-45, Georgia Agricultural Statistics, Bulletin 543, Georgia Agricultural Extension Service; 1950, Georgia Crop Reporting Service.

†*Farm Implement News*, June 30, 1949.

As a whole, acreages of row crops have, during these years, decreased proportionately, but yields per acre have increased. Yields of these crops have increased from 18 per cent, in the case of peanuts, to 56 per cent in the case of cotton. Corn yields have increased 48 per cent since 1924, and tobacco yields 46 per cent. . . . .

"There are several other significant changes which are taking place in Georgia's agricultural picture but I shall take the time to mention only one more. This change is in the efficiency of agricultural production. . . . The average Georgia farm worker today is producing two and one-half times as much as the average farm worker produced 25 yr ago. . . . . Other factors such as mechanization, wiser use of fertilizers, etc., have also played an important part in this development."

Data‡ on seed harvested in 1939 and 1949 show the increase in cover crops used in Georgia:

Seed harvested	1939, pounds	1949, pounds
Blue lupine	0	36,800,000
Crimson clover	590,000	4,000,000
Lespedeza	1,595,000	19,100,000

Even with these quantities of seeds harvested, the demand in recent years has exceeded the supply. Prices of crimson and Ladino clover, fescue and other grass and legume seeds have been quite high. More combines are needed to help harvest additional acreages of these seed crops.

Mechanization has made possible most of the rapid progress cited above. But, as the shift to tractor equipment has just begun, we can expect this to be only the beginning in establishing better conservation cropping practices throughout the Southeast.

Why Conservation Methods Are Essential. Continuous row-cropping on farm land in this area is conducive to soil deterioration on most fields. The chief causes of soil depletion are runoff, erosion, decline in organic matter, poor soil structure and leaching of plant nutrients. Row-cropping alone offers little aid in the prevention of these destructive forces.

We know from the work of Yarnell (7) and others that the erosive thunderstorm rains occur most frequently in the spring and summer months. Protective measures for runoff and erosion control are needed most at this season of the year when row crops occupy the land.

Land that is exposed to the sunshine and frequently stirred is more susceptible to organic matter depletion than that covered with thick-growing crops. Also, row crops normally return only small increments of organic material to the soil. Soil structure is closely associated with the organic matter content. With rapid destruction and little return of organic material through row-cropping there is no opportunity to improve the physical condition.

All of these factors add up to reduced production. Conversely, the prevention of runoff and erosion, the buildup of organic matter, the addition of fertilizer elements and the development of a good soil structure result in increased yields.

The erosion patterns throughout the year from different crops grown on Cecil sandy clay loam soil with a slope of 7 per cent, with 70-ft slope length (approximate distance between terraces) at Watkinsville, Ga., are shown in Fig. 2. The length of record for each crop grown is listed in the figure.

Where cotton was grown continuously, the erosion was greatest in summer, moderate in winter and spring, and light during the fall. The average annual loss was 22.85 tons per acre.

A 3-yr rotation of oats and sown Kobe lespedeza, volunteer lespedeza and cotton greatly reduced this soil loss under the same soil and rainfall conditions. The average annual erosion losses from the crops in this rotation were:

Oats and sown lespedeza	3.59 tons per acre
Volunteer lespedeza	0.22 ton per acre
Cotton	6.35 tons per acre
Annual average	3.39 tons per acre

This average annual loss of 3.39 tons per acre, from the rotation, compared to 22.85 tons per acre from continuous cotton represents a reduction of 85 per cent. Within the rotation, the excellent cover of volunteer lespedeza was the most protective; cotton the least.

‡Based on estimates by the Georgia Crop Reporting Service.

Three years of records on our runoff plots indicated that by ripping the lespedeza stubble in preparation for the row crop, the soil loss from the cotton was reduced by 56 per cent. Other problems such as cloddiness, poor stands, excessive weed growth and reduced yield accompanied this ripping practice, however. Additional tillage studies here have not produced information to date that indicate special tillage methods with equipment presently available are yet superior to conventional practices with the cropping sequences used.

Improved cropping practices made practical by mechanization appear at this time to offer the greatest possibilities for conservation benefits. Many rotations with varying degrees of ground cover are available to farmers of the Southeast. Hendrickson et al (5) showed that as the ground cover was increased with adapted legumes and grasses in crop rotations, runoff and soil losses were decreased and crop yields increased. These cropping practices included rotations of 1-, 2-, 3- and 4-year cycles containing sequences of row crops such as cotton, corn, peanuts and grain sorghum with close-growing crops like vetch, Caley pea§, crimson clover, crotalaria, Kobe lespedeza, small grain, tall fescue grass, Ladino clover and kudzu. Each rotation described has within it the desirable features of plants giving ground cover during part of the rotation cycle and the return of organic matter to the soil. Many reduce the number of row-crop years on the land.

Only through mechanization can such cropping practices as these be widely established. Included in the equipment needs for this type of farming are power and tools for

1 Tillage of sod lands
2 Planting, fertilizing, cultivating and harvesting row crops
3 Broadcast drilling of seeds of legumes, grasses and small grains
4 Making broadcast applications of fertilizers
5 Mowing and other forms of weed control
6 Haymaking
7 Combine harvesting a variety of seeds.

These operations should be performed within terrace in-

§This Caley pea is the same as the wild winter pea referred to by Dr. H. H. Bennett, and is also known as Singletory pea.

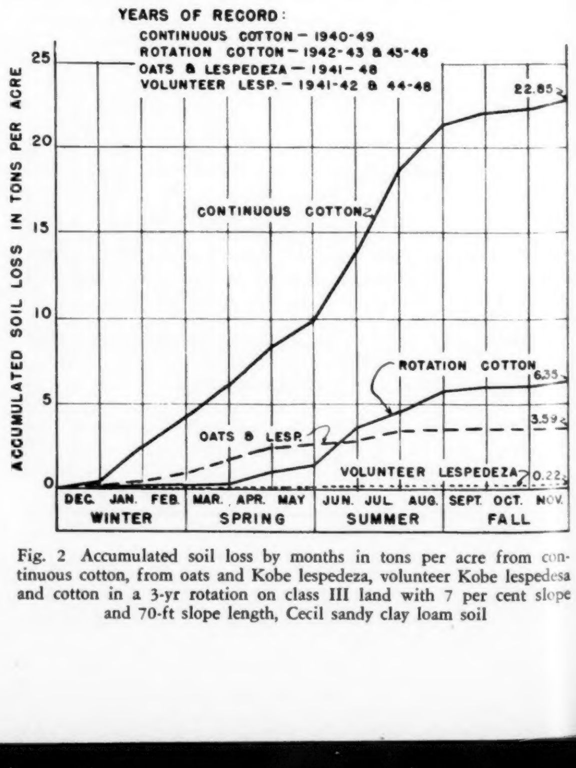

Fig. 2 Accumulated soil loss by months in tons per acre from continuous cotton, from oats and Kobe lespedeza, volunteer Kobe lespedesa and cotton in a 3-yr rotation on class III land with 7 per cent slope and 70-ft slope length, Cecil sandy clay loam soil

tervals to avoid damage to the terraces and reduction of their channel capacity. No substitute has yet been found for terraces and disposal areas for handling surface runoff water from sloping cultivated land in the Southeast.

The production of a variety of crops requiring contour cultivation and many short rows in narrow irregularly shaped field areas between terraces is typical of our row-crop farming methods in the hilly sections. The introduction of new crops into the farming system creates new problems for farmers engaged in conservation programs. However, the power controls and the quick-attaching features of implements available today are distinct aids in alleviating many of these problems. Much research and development work lies ahead of the farm equipment industry, government agencies and others to develop the best and simplest machines and techniques for obtaining maximum conservation benefits in our farming program.

Mechanization of a Family-Sized Farm. The problems faced and the benefits derived from a conservation farm plan are exemplified on the 100-acre farm unit (4, 5) of the Southern Piedmont Conservation Experiment Station at Watkinsville, Ga., which was mechanized in 1948.

This experimental farm unit has an impressive 9-year record of proof that farming is practical and profitable when based on the previously stated concepts of conservation farming. Cropping on 67 acres include the following practices:

Gentle slopes — 15 acres: a 2-year rotation of (a) wheat and Kobe lespedeza and (b) cotton or corn.

Moderate slopes — 27 acres: a 3-year rotation of (a) oats and Kobe lespedeza, (b) oats and volunteer Kobe lespedeza, and (c) cotton, corn or grain sorghum.

Steep slopes — (no rotation): alfalfa 5 acres, sericea lespedeza 12.5 acres, and kudzu 7.5 acres.

Other land usage includes 12 acres of pasture and a one-acre pond. Woodland and the homestead occupy the remaining acreage.

All the crops grown except the lint from the cotton are useful for livestock feed and grazing. Therefore, the entire cropping program, designed for its conservation benefits, makes a livestock enterprise possible on this farm. Manufacturing grade milk is sold from 12 cows.

The limited acreage of row crops, the variety of crops grown and the small herd of dairy cows spread the labor load throughout the year. The peak labor demand and greatest rush is in the fall for harvesting the cotton and corn and planting small grains.

The power requirements for small-grain planting was the determining factor for the size tractor to use on this farm. The equipment used includes an 18-dhp tractor, one-row planter with fertilizer attachment, one-row cultivator, double-disk plow, 6-disk single-gang harrow, tandum disk harrow, 10-row grain drill, 5-ft mower, side-delivery hay rake, broadcast fertilizer distributor and a tractor-drawn wagon. A power duster, hay baler and combine harvester are hired as needed. Enough time is available through the cultivating season to work off the farm with this tractor and equipment in exchange for those items hired.

Price changes, increases in the dairy herd, and other factors make it impossible to compare directly the income on this unit for the first 7 years when mules were used and the last 2 years with tractor operation. However, certain advantages are apparent with the tractor and allied equipment. These include:

1 Better, more timely and quicker land preparation, planting, fertilizing and cultivation of crops

2 Time and equipment for exchanging work to pay for hired combine, hay baler and power duster

3 Time and power for developing new and improving old pastures.

4 More time for care and handling of livestock

5 Less fatigue to farmer and his family

6 Increased assurance that the desired cropping plan can be followed each year regardless of variable weather hazards.

Gross income in 1949 on this unit was $5,627. Of this, $2,693, or 48 per cent, was derived from direct sales of crops; $2,525, or 45 per cent, from the cows, and the remainder from other sources. Gross expenses were $1,780, giving a farm income of $3,847 for labor and capital return.

In addition to a profitable return, the farming system employed on this unit provides reduced runoff, adequate erosion control, increased organic matter content of the soil, better soil structure, higher crop yields and good distribution of labor. Mechanization of the production practices and utilization of the crops through livestock make these benefits possible.

SUMMARY

Mechanization of farms in the Southeast has increased rapidly in recent years.

Tractors with mounted and drawn implements are now available to do the heavy work required in establishing and maintaining cropping practices that are an essential requirement for conservation farming.

The newer conservation methods include the use of sod crops in rotations with row crops, a very effective way to reduce runoff and erosion and also increase soil fertility and crop yields. Only through the use of mechanized equipment can such crops be widely used on tilled land.

A mechanized 100-acre farm unit on the Southern Piedmont Conservation Experiment Station at Watkinsville, Ga., that was managed for maximum conservation benefits showed that advantages with machinery included better work, more timely operations, less fatigue to operator, ability to follow the desired cropping plan and a profitable return from the farming operations.

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The Role of the Practicing Engineer

THIS generation of engineers may well play a decisive role in determining whether our free economy will survive. For engineers contribute much of that unusual ability which will be needed in the solution of the great problems of our time. The productive genius of engineers will largely determine the potential rate of economic progress, since the causes of increasing productivity can be traced largely to technology. Engineers can make a necessary improvement in the control of employment fluctuations in which the cost of capital investment is a key factor. The solution of labor-management disputes requires the production of additional revenue to which the engineer can make an important contribution. The reconstruction of foreign countries and the development of backward areas will require the know-how of the American engineer. He will play an important role in sustaining and strengthening the armed might of democracies all over the world to meet the challenge of the rising tide of destructive forces beyond the seas.

What a challenge this is to the engineering profession! If my estimate of tasks to come is correct, we shall in future need more men of good training, of basic ability and broad understanding.... They will require great skills of an administrative and economic nature. Thus we shall need to train people not merely to preserve our economic system, but to improve and perfect it for the maximum good of all the people. —Lawrence A. Appley in *Journal of Engineering Education,* June, 1950.

The Depth and Spacing of Tile Drains

By C. S. Slater
MEMBER A.S.A.E.

ALTHOUGH drainage engineers have worked out in considerable detail the mechanics and hydraulics of tile drainage, it appears that the adjustment of the depth and spacing of tile lines to the drainage requirements of different soils is still largely a matter of personal experience and judgment. References on drainage are generally lacking in specific information on this phase of the subject.

Such information as is available usually is given in generalized statements. One can find statements to the effect that tile will draw laterally a distance of about one foot for each inch of depth to the tile, or that tile may be placed deeper and farther apart in sandy soil than in clay. The latter statement may be hedged by the further information that sandy land can be overdrained. Advice is sometimes given that in the absence of the known behavior of tile on similar soil, tile should be laid at different depths and spacings to observe the results for a period of years before undertaking large-scale operations. Unfortunately, advice of this sort is not applicable generally to the recurrent problem of providing suitable tile drainage in small and isolated areas.

Attempts have been made to determine the proper depth and spacing of tile on the basis of measurable soil characteristics. Perhaps the best known of these is the work by Neal (13, 15)* who gaged the depth and spacing of tile by measurements of soil plasticity and clay content. It is known, however, that these measurements are related only in a general way to soil permeability and drainage behavior, so that the measurements are at best but doubtful indices of what the depth and spacing of tile should be for specific soils. A much more logical approach has been made by Donnan, Aronovici and Blaney(2, 7, 8). They have developed a tile-spacing formula that is based on soil permeability and the application of Darcy's law to the conditions of lateral flow. Initial tests of their equation, based on measured flow from tile lines, have shown a satisfactory agreement between the actual and the computed spacing of tile under field conditions(8). Essentially the same equation also appears in Dutch literature(9).

Soil physicists meanwhile have clarified certain water relationships of soil with respect to the effects of tension on drainage(5, 6, 10, 12, 16), and have provided a logical basis for determining the depths of soil from which free water must be removed if drainage is to be effective. Other investigators have developed methods and criteria for determining the permeability of soils (1, 4, 11, 14, 17).

With the information that is available now, it should be possible to develop a systematic procedure to determine the drainage ability of soils and the approximate proper depth and spacing of tile drains for different soil conditions. The following discussion is an attempt in that direction. However, the reader should recognize that the details of procedure as presented are adapted primarily to the drainage conditions of humid areas. In this connection, certain factors have been limited arbitrarily and these limits ultimately may require modification in broader applications.

The Equation for Lateral Flow. The proposed procedure is based largely on an understanding of the equation for lateral flow and its limitations. For uniform conditions of permeability above a barrier layer as shown in Fig. 1, the formula may be written

$$S^2 = \frac{4P(b^2 - a^2)}{v}$$

This paper was prepared expressly for AGRICULTURAL ENGINEERING.

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* Numbers in parentheses refer to the appended references.

where S is the distance between drainage lines, P is the permeability of the soil, v is the rate at which a depth of water is to be removed from the area that is to be drained, b is the distance from the barrier layer to the drawdown curve at its midpoint, and a is the distance from the barrier layer to the drawdown curve at the tile line; or, more accurately, it is the depth of water in an escape ditch that extends from the barrier layer to the ground surface. Briefly then (for the conditions of Fig. 1, and if we assume that tile are as effective as an escape ditch in removing water at the plane of a) the proper spacing of tile can be calculated by determining

1 The permeability of the soil. Variations in permeability also determine the location of the barrier layer

2 The depth at which the tile should be placed. This allows for the determination of the quantity a

3 The depth of soil above the water table that must be drained at the midpoint between the tile lines. This allows for the determination of the quantity b

4 The rate at which water is to be removed from the area. This fixes the value of v.

Derivation of the Formula†. According to Darcy's law, the flow of water through a column of soil is expressed by the equation $v = P(h/l)$, where v is the rate of transmission per unit of area. It is equal (in linear measurement) to the depth of water that is transmitted in unit time. P is the permeability constant, h is the hydraulic head, and l is the length of the soil column through which the water moves. It is necessary to identify these quantities in the diagram of Fig. 1 in order to derive the equation for lateral flow.

Consider first only the section that lies above the plane of the tile, and let v_1 be the corresponding depth of water per unit of time to be removed from the land area that is represented by the distance O.5S. As this depth of water escapes laterally along the face of the drawdown curve, it is confined to a vertical section that is represented by the distance b-a. In this section then, for lateral flow, the v of the Darcy equation may be represented by the expression, $v_1(0.5S[b\text{-}a])$.

A further study of Fig. 1 will show that the lateral pressure gradient in planes at all points along the line b-a (the h/l of the Darcy equation) is equal to the ratio, $(b\text{-}a)/0.5S$. This is the ratio that would hold if the water at all points along the line b-a traversed the whole distance laterally from the line to the drawdown curve. However, two mutually cancellable factors should be introduced into the expression as a matter of accuracy. One is based on the premise that *on the average* water that is transmitted laterally at any plane in the section under discussion is moved only half the distance from

† The formula is derived elsewhere in slightly different form by the methods of integral calculus(2, 7). The derivation given here has no advantage other than that of mathematical simplicity.

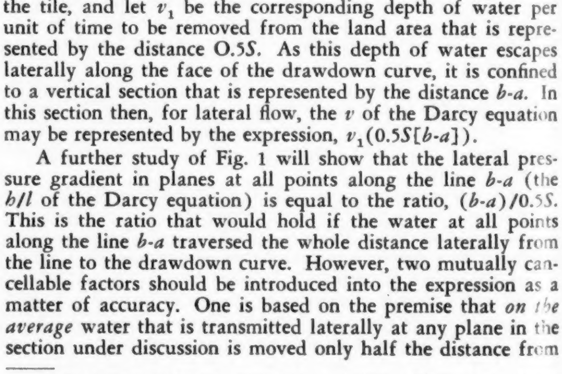

Fig. 1 Diagrammatic identification of terms used in tile-spacing calculations

the line *b-a* to the drawdown curve. The other is based on the premise that the water is delivered *on the average* at a point that is only half the distance from the midpoint of the drawdown curve to the tile line. Consequently, in calculating the delivery of water to the escape ditch, the expression should be multiplied and divided by 2, which would, of course, put us right back where we started.

Now, making the necessary substitutions in the Darcy equation, we can write $v_1(0.5S/[b-a]) = P([b-a]/0.5S)$

or $v_1 = (P\,[b-a]^2)/0.25S^2$ .... [1]

This equation will be referred to later in the discussion.

Consider now the section that lies below the plane of the tile and let v_2 be the depth of water per unit of time that this section will remove by lateral drainage from the land area that is represented by the distance $0.5S$. As this water escapes laterally along the face of the escape ditch, it is confined to a vertical section that is represented by the distance a. In this section, then, the v of the Darcy equation becomes, for lateral flow, $v_2\ (0.5S/a)$.

The corresponding lateral pressure gradient in planes at all points along the lines a (the h/l of the Darcy equation) appears to equal $(b-a)/0.5S$. That is to say, this is the ratio that would hold if all the water traversed the full distance of the line $S/2$. However, since water is removed from all sections of the land surface represented by the line $S/2$, *the average distance* through which the water passes in order to reach the escape ditch is $0.5S/2$. Therefore, to meet the special conditions of lateral flow, the effective pressure gradient is $2(b-a)/0.5S$.

Now making the necessary substitutions in the Darcy equation, we can write $v_2(0.5S/a) = P(2[b-a]/0.5S)$

or $v_2 = P(2ab-2a^2)/0.25S^2$ .... [2]

The total lateral flow in unit time obviously is the sum of equations [1] and [2]

$$v = \frac{P(b-a)^2 + P(2ab - 2a^2)}{0.25S^2}$$

Clearing, $$v = \frac{P(b^2 - 2ab + a^2 + 2ab - 2a^2)}{0.25S^2}$$

Simplifying, $$v = \frac{4P(b^2 - a^2)}{S^2}$$

Whereby $$S^2 = \frac{4P(b^2 - a^2)}{v}$$

It may be well to note at this point that when numerical values are substituted for the quantities in the equation, it is necessary to express P and v in identical units. Thus if P is expressed in inches per hour, then v must also be expressed in inches per hour. However, P and v may be expressed in any other unit of rate without affecting the validity of the equation. S will always be determined in whatever unit of length is used to identify b and a.

Advantages and Limitations. The chief advantage of the formula for lateral flow is its relative simplicity. To understand the derivation given here requires a minimum of experience in mathematics. More accurate expressions for flow in porous media can be derived on the basis of hypothetical equipotential lines and the use of higher mathematics, and those who understand the more complicated forms should be encouraged to use them. But understanding is an essential part in the practical application of any formula that applies to soils, since field conditions never match the hypothetical considerations on which formulas are based. It follows that the simpler expression, although of only approximate accuracy, is frequently the more useful.

A limitation of the formula is its failure to account for the restriction in flow that must occur when the water converges to a tile line instead of passing freely into an escape ditch. The error from this source increases as values for a are increased. The formula fails to account also for lateral flow that may take place under tension just above the free water surface along the drawdown curve(7).

The Formula and Variable Permeability. The usefulness of the general formula for lateral flow in practical applications may be questioned because soils are seldom found with the uniformity of permeability that was assumed in the derivation of the formula. Soils are commonly characterized by profiles that are made up of horizons of variable permeability. In this connection, the stepwise derivation of the formula as given makes use of a procedure that can be expanded to estimate the lateral flow in a soil profile of striated permeabilities. The procedure is illustrated in the manner in which values of v_1 and v_2 were calculated separately for the sections (or horizons) above and below the plane of the tile. However, since the permeability of the soil layer at the depth at which the tile is placed governs the rate of flow to a marked degree (because of the concentric nature of the flow as it approaches the tile), the permeability of that layer only will be considered as governing lateral flow throughout the whole soil depth in the present discussion. Variations in permeability need to be considered only in determining the depth at which the tile should be placed.

Determination of Soil Permeability. Since the use of the formula to determine spacing of tile for different soils is dependent on their permeabilities, this soil characteristic should be determined with as much precision as circumstances will permit. A choice of methods is available, but frequently installations will have to be based on the soil conservation survey classifications of permeability. O'Neal(14) has reported on observational methods of classifying soil permeability and gives the following permeability classes and corresponding rates:

Class	Rate, inches per hour
Very slow	Less than 0.05
Slow	0.05 to 0.2
Moderately slow	0.2 to 0.8
Moderate	0.8 to 2.5
Moderately rapid	2.5 to 5.0
Rapid	5.0 to 10.0
Very rapid	10.0 or more

It will be seen later that the substitution of these rates in the formula for lateral flow aids in forming a concept of the classes of soil that can be drained by tile installations at reasonable depths and spacings.

Location of the Barrier Layer. The location of a barrier layer must be determined before practical use can be made of the formula for lateral flow, since the values of b and a are dependent on it. Occasionally the barrier layer can be identified easily by noting sharp changes in the structure and texture of the soil. In other cases the barrier layer is more difficult to locate. It happens frequently that the permeability of the soil decreases gradually with depth. In this case any layer of soil in the slow or very slow permeability class may be considered a barrier layer. If more permeable zone extends appreciably below the depth at which tile may be placed, the presence of an arbitrary barrier nearer to the tile must be assumed to adjust for the constriction in flow that takes place in the vicinity of the tile. In such cases the assumption of a barrier layer at a depth 2 ft below the plane of the tile appears to be reasonably satisfactory. Admittedly more information is needed on this point.

Depth at Which Tile Drains Should be Placed. The depth of tile placement is governed by engineering and soil considerations. The tile should never be laid less than 2 ft deep solely as a matter of protecting the tile system. How much deeper tile can be laid is governed frequently by the elevations at which outlets must be placed. If tile are laid deeper than 5 ft, the cost of laying the tile increases sharply, particularly if any difficulty is encountered in the caving of trench walls. Engineering considerations in general reduce the question to this: At what depth between 2 and 5 ft shall the tile be placed?

Other considerations, based on soil properties, affect the depth of tile placement. Drainage lowers the water content

of the soil above the water table as the depth to water table increases, in accordance with the drainage characteristics of the soil(16). Light-textured soils, and organic soils where the water table must be kept high to prevent subsidence, can be overdrained. Except for these special cases, the deeper the tile are placed in soils of uniform permeability, the better for most crops. Loams and heavier soils have water-holding capacities great enough to make them drought resistant without benefit of the fringe water that is brought up by capillarity from the water table, and lowering it has the effect of deepening the soil that is suitable for root growth.

Variations in permeability within the soil profile govern to a large extent the depth of tile placement in the heavier soils. Consider the case of a soil that has a decreasing permeability with depth. The choice of tile depth lies between the two extremes of (a) placement of the tile at the surface where the value of b^2-a^2 in the equation for lateral flow becomes zero and (*b*) deep placement where the value of *P* becomes zero. The correct depth, based on the formula for lateral flow and within the limits set by engineering considerations, is the one where calculations based on the formula show the largest value for *S*, the tile spacing.

In soils having a markedly striated permeability the same type of reasoning applies. It results usually in placing the tile in the most permeable zone within the limits fixed by engineering considerations, provided that no soil above that depth is less than slowly permeable. In practice, the calculated depth should be decreased in some cases to avoid laying the tile on an impermeable stratum. The tile obviously should be surrounded by permeable soil to reduce resistance in the zone of constricted flow around the tile.

Determination of the Value of a in the Equation for Lateral Flow. Fixing the position of the barrier layer and the determination of the depth at which the tile are to be placed gives by difference the value of *a* in the equation for lateral flow.

Determination of the Value of b in the Equation for Lateral Flow. The value of *b* in the equation for lateral flow is the distance from the barrier layer to the top of the water table at the midpoint between tile lines. This is the point or line of minimum drainage in the field. In practice, *b* is not a fixed value but varies with seasonal water conditions. Consequently a value of *b* should be accepted for calculation purposes that will give an adequate rate of drainage when moisture conditions are critical. That is to say, we must base our spacing *S* on the rate of drainage that is needed when the water table is at or near the soil surface. Conditions become critical generally if the water table rises to within one foot of the surface even for short periods of time. The value of *b* to be used in calculations of tile spacing is one foot less than the distance from the barrier layer to the ground surface.

Determination of v in the Equation For Lateral Flow. Experience in tile drainage indicates that tile drainage systems should be designed to remove from 0.01 to 0.015 area inches of water per hour(3). Since these design rates are based on maximum conditions of flow when the land is flooded or partially flooded and equal the carrying capacity of the tile, the lowest rate given serves as an acceptable value of *v* for calculation in the equation for lateral flow under the conditions described in the preceding paragraph.

Determinations of Tile Spacings. When values have been fixed for *P*, *b*, *a*, and *v*, as described above, values for *S* are easily determined. The following table shows the approximate spacings required by formula when tile are placed at depths of 3, 4, and 5 ft in soils of uniform permeability with a deep barrier layer more than 7 ft below the soil surface. In making the calculations, the barrier layer is assumed to be 2 ft below the depth at which tile is laid for stated reasons. Thus the value of *a* is fixed at 2 ft, *b* is one ft less than the depth from the soil surface to the assumed barrier layer and *v* equals 0.01 iph.

Permeability class	Permeability	Tile spacing, in feet, for tile placed at depth of 3 ft	4 ft	5 ft
Very slow	0.0 to 0.05	0 to 15	0 to 20	0 to 25
Slow	0.05 to 0.2	15 to 30	20 to 40	25 to 50
Moderately slow	0.2 to 0.8	30 to 60	40 to 80	50 to 100
Moderate	0.8 to 2.5	60 to 110	80 to 145	100 to 180
Moderately rapid	2.5 to 5.0	110 to 155	145 to 205	180 to 255
Rapid	5.0 to 10.0	155 to 220	205 to 290	255 to 360

The following example is illustrative of calculations for a soil having striated permeability:

Permeability of top 2 ft, 2 iph

Permeability of next 1.5 ft, 0.5 iph

Permeability below 3.5 ft, 0.1 iph

For tile at 3 ft, $a = 0.5$ ft, $b = 2.5$ ft, $P = 0.5$ iph, and $v = 0.01$ iph.

For tile at 4 ft, $a = 2$ ft, $b = 5$ ft, $P = 0.1$ iph, and $v = 0.01$ iph.

Making the corresponding substitutions in the equation for lateral flow:

$$S^2 = \frac{4 \times 0.5(2.5^2 - 0.5^2)}{0.01}, \; S = 35 \text{ ft}$$

$$S^2 = \frac{4 \times 0.1(5^2 - 2^2)}{0.01}, \; S = 29 \text{ ft}$$

We conclude that this soil is more easily drained with tile at 3 ft than it is with tile at 4 ft.

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Drainage of Sugar-Cane Land

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THE need for drainage on sugar-cane land in Louisiana has been recognized for at least a century. The Agricultural Year Book for 1855, commenting on the failure of the sugar-cane crop in Louisiana that year states "These defects, it is conceived, are not attributable alone to untimely frosts but mainly to injudicious cultivation, such as neglect of proper drainage, etc." In proposing a plan for restoration, the following comment is made: "The perfection of culture of sugar cane, like that of Indian corn, consists in returning to the soil on which it grows, through the medium of fertilizers, the whole of the essential substances extracted from it by the preceding crops, the eradication of noxious weeds, and the prevention of the accumulation of stagnant water." Such comments in pointing to the drainage problem, emphasize the unusual conditions that exist in Louisiana agriculture. Drainage is difficult in the first place because of exceedingly high rainfall. The rainfall records covering the sugar-cane area of Louisiana for the period 1899 to 1938 show that the average annual precipitation is 60 in or more per year, that the average number of days with 0.01 in or more of rain is 120 days per year, and that the maximum in one month ranges from 15 to 20 in and the maximum rain for 24 hr ranges from 10 to 12 in. In the second place, a number of the soils are highly impermeable. Several permeability ring tests have been made in sugar-cane middles (low area between rows) and the amount of percolation into the soil was so slight as to be immeasurable. These climatic conditions make surface drainage the prime problem faced by sugar-cane growers.

This paper was presented at meetings of the Southeast and Southwest Sections of the American Society of Agricultural Engineers, respectively, at Biloxi, Miss., in February and at Baton Rouge, La., in April 1950.

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A century ago this problem was met by the use of lateral ditches with some form of outlet. These lateral ditches generally ran with the slope of the land, varying considerably in spacing from 100 to 250 ft. They ranged from 18 to 36 in in depth with approximately 4-ft tops and 2-ft bottoms. Until 1940 they usually were dug by hand. Since the cane was grown in rows 18 in high, 6 ft apart and parallel to the lateral ditches, it was necessary to have cross drains or ditches cutting through the rows to carry the water to the lateral ditches. There were generally four of these ditches (known as quarter drains) to the cut. The outlets were some type of excavated channel leading to swamps or bayous; in some instances, the lateral ditches emptied directly into the swamp or bayou.

This drainage system is still in use with improved outlets. However, a century of sugar-cane production has gradually changed the land pattern, and this has greatly impaired surface drainage. The earth from excavating lateral ditches has built up the ditchbanks until they are higher than the center of the cuts. (A cut is the area between two lateral ditches and the two access roads, known as headlands, approximately 100 to 250 ft wide by 1000 ft long.) Likewise, tillage operations have built up the headlands. Implements form holes when they enter the ground and deposit earth on the headlands when they leave the soil. Since, in general, the tillage operations have continued in one direction, the implements enter and leave the soil at the same location for each operation year after year. This continues to deepen the holes and raise the headlands. The project has taken a number of levels over cuts on various plantations and has found as much as 3 ft of difference in elevation between headland and the hole or pocket in the cut. The end product of excavation and tillage is, in many cases, a saucer surrounded by ditchbanks and headlands higher than the cultivated part of the cut. In order to remove the water from the cuts, deeper quarter drains are required, which even when deepened in many cases only partially remove the water. Water is left standing in the holes

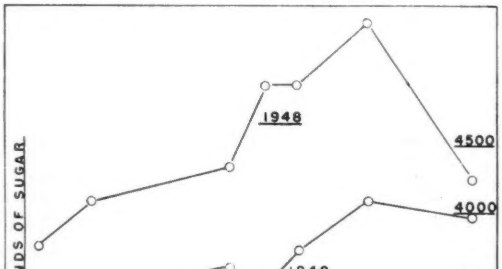

Fig. 1 Amount of crown versus yields, Smithfield 1948-49

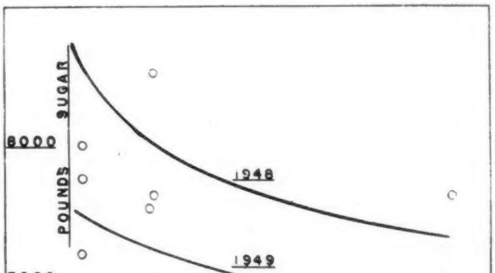

Fig. 2 Precision of grading versus yields, Westover 1948-49

and pockets until it either evaporates or percolates into the soil. Low soil permeability lowers the rate of percolation.

The wet field condition caused by the partial removal of water induces such cane diseases as red root rot and phytophythora rot. The high potential producing varieties of cane, such as CP-3613, are very intolerant to wet conditions and are recommended only for well-drained sites. Where pockets and holes are located in the field the growth is very small, and often the cane in the entire pocket will perish. Also, the deeper quarter drains interfere with tillage operation. Tractors have difficulty in crossing the drains, and broken axles are common. It is necessary for tractor operators to slow down to cross the quarter drains and to lose considerable time, which in turn increases the cost of field operations.

The acute problem of surface drainage presented by the unusual climatic and soil conditions in Louisiana and by the influence of changing land patterns on the drainage system, has led the American Sugar Cane League and interested sugar planters to request experimental work. Research has been carried on by the U. S. Department of Agriculture, Soil Conservation Service (Research), and the Louisiana Agricultural Experiment Station. This joint undertaking has concentrated on two phases of surface drainage: The grading of land for drainage and the construction and maintenance of lateral ditches.

GRADING SUGAR CANE LAND

Grading of Sugar-Cane Land for Drainage. It was thought that it might be feasible to grade the cuts to solve the deep quarter drain problem. It was further conceived that the grading should move the earth from along the lateral ditches to the center of the cuts, at the same time sloping the earth from the center of the cut towards the lateral ditches. The cut would then have a crown similar to a highway, often spoken of as turtlebacking, and the quarter drain would consist only of an opening through the rows without a channel through the middles where the tractor wheels run.

A test area of 6.4 acres was set up and worked in 1944 on the St. Delphine Plantation at Addis, La., in order to investigate the feasibility of such grading. A further purpose of this test area was to ascertain the limitation and problems incurred in grading sugar-cane land and also its effect on yields.

The test area was planted to corn in the spring of 1945, and after the corn harvest it was planted to sugar cane in the fall of the same year. A check area, which was not treated, was planted at the same time. The corn yield on the graded test area was approximately double that of the check area. The cane yield in the fall of 1946 showed an increase of 4.48 standard tons of cane and 922 lb of sugar over the ungraded check area. The increase in yield of sugar per acre was higher than the increase in yield of cane tonnage per acre.

The exceptional success of this first test area indicated that the grading of sugar-cane land for drainage had possibilities, and additional test areas were planned. A number of problems and questions were in evidence. In the first place, the results of the first test area had to be verified by repeating the experiment on a larger scale and on various types of land. Also certain technical problems were present, such as the proper amount of slope for a cut, the precision required in grading the cuts, and the most adaptable equipment for the work as well as the most satisfactory methods of using it. Finally, it had to be determined if the cost of the work on a volume or plantation basis would make this kind of grading practical.

Yields. Yield records have been kept on 105.6 acres of graded sugar-cane land in test areas and on comparable check areas. The test areas included sandy, mixed, and heavy black lands. The areas planted to corn prior to going into sugar cane yielded the following averages: graded areas, 47.2 bu per acre, and check areas, 27.2 bu per acre — an increase of 20 bu. The corn was planted on 6-ft rows and interplanted with soybeans, the usual practice in the sugar cane area.

The average increase of the sugar-cane test areas (1946 to 1949, inclusive) was 5.84 standard tons of cane and 1267 lb of sugar. This included both plant and first year stubble cane and the cane varieties CP 34-120, 29-120, 36-105, and 36-13.

One exceptional test area, consisting of 47.2 acres of CP 36-13, averaged 52.49 standard tons of plant cane per acre and 38.74 standard tons of first-year stubble cane. This is an average yield of 45.61 tons per acre for the two crops. The plantation's acreage of sugar cane, 1231 acres per year for two years, averaged 25.42 tons per acre.

These yield records, based on large-scale test areas, are comparable to those of the first test area. Moreover, they cover the various types of sugar-cane land and the more common cane varieties. It can be concluded then that grading of sugar-cane land for drainage will increase yields materially.

TECHNICAL PROBLEMS

Slope. In order to determine the proper amount of slope in grading, one of the test areas was worked so as to give to separate cuts different amounts of crown. Fig. 1 is the yield curve for this area for plant and first-year stubble. It will be noted that the yield increases as the slope increases up to 13 in per 100 ft. When the slope increases above 13 in per 100 ft, the yield drops. It is further noted that with the first-year stubble the curve flattens. This inconsistency, it is thought, is due to the fact that the raw soil areas along the ditchbanks, exposed by grading, become weathered and more conducive to plant growth.

Precision of Grading. One test consisted of 12 cuts of practically the same amount of crown. The precision of grading varied considerably between cuts. The area was planted to CP 36-13, a cane which is very intolerant to wet conditions. Every ponded area or pocket was in evidence during the growing season. The cane was less vigorous and in some cases the stand was sparse.

The yield records of this area for 1948 further exemplified the condition. After harvest the project ran a number of levels over this area. Fig. 2 is a graph showing yields plotted against the percentage of ponded area, two inches or over. Ponded or pocketed areas, two inches or over, are areas that have earth, two inches or higher, between them and the lateral ditches. It will be noted that both the yield of cane and the yield of sugar decreases as pondage increases.

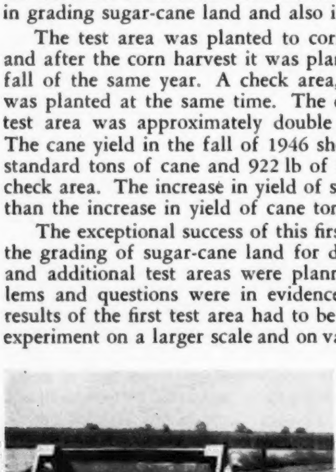
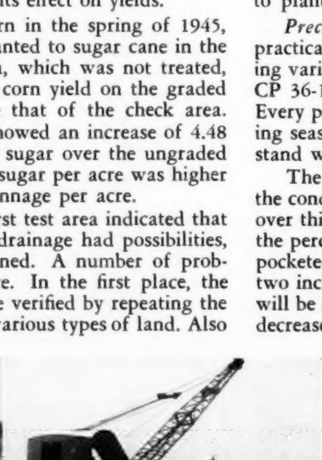
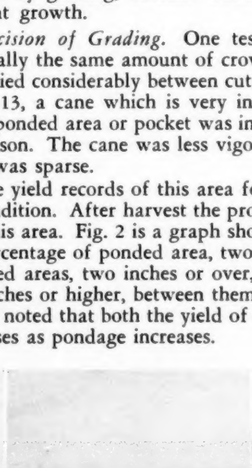
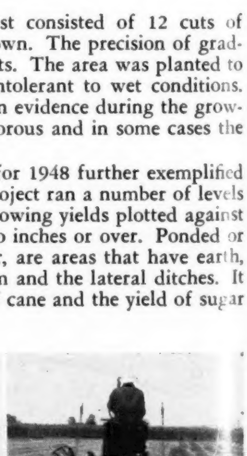

Fig. 3 (*Extreme left*) Grading sugar cane cut with scraper and motor grader • Fig. 4 (*Center, left*) Cutting lateral ditches with straddle dragline and sloping side bucket • Fig. 5 (*Center, right*) Completed dragline ditch • Fig. 6 (*Extreme right*) Marking out graded sugar cane cut




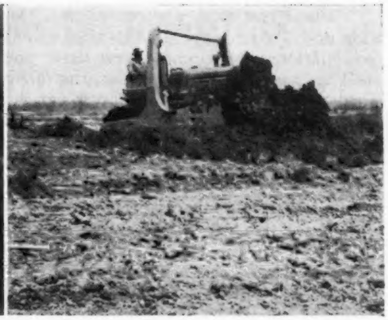

Fig. 7 (*Extreme left*) Experimental wheel trencher equipped with wide tracks, power-sloping attachment and high-speed impeller for spreading the earth • Fig. 8 (*Center, left*) Crowning land with Parsons whirlwind terracer • Fig. 9 (*Center, right*) Cultivating sugar cane. Note high rows and quarter drain across rows • Fig. 10 (*Extreme right*) Bulldozer moving earth from canal excavation into a low area in the cut

It is almost inconceivable that ponding of only 2 in with a crop grown on 18-in rows should have such an effect on yields. However, Fig. 2 very definitely shows that precision in grading is highly important. Grading work should be done with as much precision as possible and ponded areas or pockets should be kept to a minimum.

It is further felt that there is a definite relationship between the precision of grading and the proper amount of slope. It is thought that the slope can be lessened with increased precision in grading because larger slopes tend to offset the retention of water in pockets. A barrier will cause a larger pond on a flat slope than on a steep one. Test areas covering this phase are under way, which should give more definite information. However, on a precision-graded cut a slope of 6 in per 100 ft will probably be ample.

Equipment. Field trials were made with the following types of equipment: plows, Parsons whirlwind terracer, bulldozer, heavy pull graders, and motor graders. It was found that any of the equipment listed can be used for cut-crowning work, each having its advantages or limitations. The limiting factor is the amount and location of the earth that is to be moved. Only bulldozers and scrapers are able to easily move the earth in any direction to fill holes or pockets.

Plows will move the earth toward the center of the cuts. One limitation is that their work must be supplemented with the work of a grader to move the earth next to the ditchbank. Another is that they are slow in completing the task. It requires from 10 to 20 plowings to do a reasonable job of cut crowning, depending on the previous condition of the land. The best method in grading cuts with plows is to operate the plows so that they will always move the earth toward the center of the cut. Alternating the use of backfurrows and islands in the center of the cuts is essential to secure a reasonably uniform crown. It requires considerable experience and judgment on the part of the operator since no definite method can be prescribed due to the varying conditions of the cuts.

Parsons whirlwind terracing plow completes the task much faster since it pitches the earth. Again it is necessary to supplement the work with a grader to move the earth from along the ditch bank. Neither the plow nor the Parsons whirlwind terracer will move the dirt lengthwise of the cuts to fill the pockets. The method to use with the terracer is similar to the method described for plows. However, in general four times over the cut gives a satisfactory crown.

Bulldozers move the earth faster than any other equipment tested; also, earth can be moved lengthwise of the cut into the pockets. They require a skilled operator, however, and some difficulty is experienced in moving the earth from along the ditchbanks. When the bulldozer is used by itself in grading, the earth is cut loose next to the ditchbank by operating the implement parallel to the lateral ditches, when a load of dirt is loosened, the dozer is turned and the earth is pushed toward the center of the cut, wasting the earth so as to create a crown. Another method sometimes used is to hook the blade over the loosened earth and, with the tractor operating backwards, the earth is then pulled to the center of the cut. Special reverse blades have been developed for this type of operation and are called "pulldozers".

Heavy pull graders do the most complete job of cut crowning filling the small pockets automatically to a great extent as the crown is formed and leaving the surface reasonably smooth. They are slower than the bulldozer. Another disadvantage is the length of the equipment; the long train of equipment is hard to handle and much time is lost in placing the equipment for operation. Also two operators are required, one on the tractor and one on the grader. With the blade set at an angle, the earth is cut loose on the ditchbank and moved toward the center of the cut. Successive passes will build up a crown. The number of total operations from ditchbank to the center of the cut varies with the size of the cut, the amount of earth necessary to be moved and the size of the grader.

Motor graders do the job with the same perfection as pull graders. Methods of use and limitations are essentially the same as those of pull graders with the exception that since they are self-propelled and a tractor is not needed, the long train is eliminated, resulting in greater mobility. In addition only one operator is required.

Field trials to date have shown that the most adaptable combination of equipment for grading sugar-cane land with a crown is the bulldozer and motor grader. The motor grader is used to move the earth along the ditch toward the center for approximately 20 ft. The bulldozer is then used to move the earth to the center of the cut, distributing the earth as required to form a crown and also moving earth into the holes or pockets. After bulldozing, the motor grader is used for smoothing the cut.

At the present time field trials are under way using two other types of grading equipment. The *4-yd wheel-type scraper* is proving to be promising since the cut and distribution of the earth can be very closely controlled. It is more applicable for moving earth considerable distances to fill the pockets. Since precision in grading has proved to be a basic requirement, field tests have been run also with a small *22-ft land leveler*, the most precise grading tool. A large *48-ft land leveler* has been procured and a number of field trials with it are contemplated this season.

COSTS

This paper, so far, has shown that grading of sugar-cane land for drainage can be expected to increase yields 5.84 standard tons per acre. With the price of sugar cane at $7 per standard ton, an average arrived at on the basis of sugar-cane prices for the past several years, this represents an increase of $40.88 per acre. On a "sugar" basis the increase is greater but manufacturing costs are involved. The paper also has outlined an effective system for such grading, indicating the most adaptable equipment and methods of use. The question of cost, the determining factor in the success of any agricultural method, has yet to be answered.

Volume cost studies were run on a 73-acre test area, 6 cuts wide and 3 cuts long. In this cost study work, two different combinations of equipment were used: one, the Parsons whirlwind terracer and motor grader; the other, the bulldozer combined with a motor grader. Costs for the Parsons whirlwind terracer-motor grader combination range from $7.30 to $12.61 per acre. The bulldozer-motor grader combination costs range from $11.72 to $25.27 per acre. The condition of cuts and the amounts of earth required to be moved vary considerably. For this reason a range in costs has been given in each case. Higher costs for the second equipment combination are due to the necessity of hiring skilled operators for both bulldozer and motor grader. The Parsons whirlwind terracer, on the other hand, can be operated by plantation tractor drivers. In order to secure the low cost with the Parsons whirlwind terracer, the machine must work three cuts long, crossing the headlands. When the machine works three cuts long, the time in turning is reduced one-third from the time involved in working a single cut. The same procedure in the case of the other combination will not reduce costs proportionately. However, the higher costs for the bulldozer-motor grader combination includes work which the Parsons whirlwind terracer is unable to do. A better job is done by the bulldozer-motor grader combination.

Costs records kept in grading other test areas verify this volume-cost study. While there is always some variation in costs due to factors already indicated, it can be concluded that the grading of sugar-cane land for drainage is practical. Even in measuring the increase of $40.88 per acre against the maximum cost of $25.27 per acre, there is a substantial margin, which makes grading a feasible practice for Louisiana sugar planters. An additional item, which can not be measured in yield returns is the increased efficiency and reduced maintenance costs of farm machines operating on graded land.

LATERAL DITCHES

The shortage of labor for cleaning, mowing, and maintaining lateral ditches became an acute problem during World War II, since practically all of this work was done by hand. Many plantation workers either went into military service or migrated to the cities, where they worked in defense plants. At present there is still a shortage of plantation labor. The sugar planters brought the problem to the attention of everyone having an interest in any phase of the problem, including state and federal research people and equipment manufacturers. To date, three aspects of the problem have been given consideration: the large number of lateral ditches which seemed excessive in some cases, the rank vegetation restricting the flow of water, and the lack of adaptable equipment for cleaning the ditches.

Number of Lateral Ditches. In order to remove the water from the cuts, which have become low in the center, planters have had to split cuts with a second ditch. A number of these cuts are now only 10 rows wide. This procedure increases the number of ditches to maintain, and a considerable amount of land is lost for cultivation. It was thought that by grading a number of split ditches could be eliminated where the cuts are narrow. A test area of eight blackland cuts was worked. The original cuts were only 13 rows in width. Six of the cuts were graded and made into three cuts; the other two were left as a check area.

The first crop was harvested from this area this year. The cuts showed an increase in yield over the check area of 7.01 tons of standard cane per acre, and 0.85 acres, originally in ditches, was put under cultivation. The increased yield had an approximate value of $49 per acre, whereas grading costs were $25 per acre. The first year's results indicate that a number of ditches can be eliminated in this way on similar narrow cuts.

Vegetation Control. Control of vegetation in lateral ditches is of primary importance because the flow of water is often seriously retarded by the growth produced by the favorable Louisiana climate. The vegetation that gives the most concern is Johnson grass. The Louisiana Experiment Station has done considerable work on the control of this grass and other weeds, both on the ditchbanks and in the cane fields. The agricultural engineering department has concentrated on the burning of vegetation with ditch burners. It is reported that light burning is more effective than heavy burning. Reasonably good control can be expected from burning the banks four times per season. Effective eradication of Johnson grass is reported also by the use of some of the commercial chlorate compounds which has been a project of the plant pathology department. The herbicide 2,4-D is very effective in eradicating broadleaf plants. The spray method differs from the other in that it eradicates, while burning controls the growth to a point where vegetation does not restrict flow in the ditch channels. Ditch burning costs $8 per mile; spraying is reported to cost $54.50 per mile.

Machines for Cleaning. The most critical aspect of the problem created by the decreasing supply of plantation labor was the cleaning of lateral ditches. No adequate machines were available at the start of the war for this work. Requirements of such a machine are that it must work alongside of or straddle the ditch; that it must place the excavated earth away from the lateral ditchbank, preferably in the center of the cut, and that it must be mobile since the yardage excavated is light and requires the machine to be on the move almost continuously.

Both the project and equipment manufacturers have worked on the problem. The project carried on the ground work. It experimented with a side arm on a D-4 Caterpillar tractor, equipped with a dragline attachment. A sloping side bucket was also developed. This bucket has the same shape as the ditch, and one pass of the bucket completely cleans the ditch for the distance it travels. The bucket was used in conjunction with the side arm. This combination excavated the ditch satisfactorily and placed the earth away from the ditchbank. The machine operated on the side of the ditch with the side arm extending over the ditch so that the bucket could be pulled up the ditch. Cable wear was excessive with this machine.

Manufacturers have used the project's recommendations so far as standards in constructing lateral ditches and placing of the spoil; moreover, they have elaborated and perfected our groundwork. Two manufacturers have developed a light widetread dragline which straddles the ditch and proves very satisfactory. They are using the sloping side bucket developed by the project, and three companies are now manufacturing it. There are approximately forty of these machines in the cane area.

The cost of cleaning lateral ditches with a dragline is approximately the same as with hand labor, the main difference being that a better and faster job of cleaning the ditches is done with the dragline. Also, the draglines are being used for hoisting cane during the grinding season, thus utilizing further the investment in the machine.

While the straddle dragline and sloping side bucket combination is the most usable machine to date under Louisiana conditions, the project has experimented also with other types of equipment, such as ditching plows and graders. They do a satisfactory job of ditching under dry conditions but are unusable, under wet conditions. Another machine, which is showing promise in project experiments, is a specially equipped wheel trencher, having devices for sloping the bank and spreading the earth.

SUMMARY

The work carried on by the joint undertaking of Soil Conservation Service (Research) and the Louisiana Agricultural Experiment Station has made substantial progress in solving the problem of surface drainage, created by unusual climatic and soil conditions in Louisiana. In the matter of grading sugar-cane land for drainage, it has been estimated by the sugar-cane specialist of the Louisiana Extension Service that approximately 70,000 acres have been turtlebacked to date with varying degrees of perfection. New methods of maintaining lateral ditches developed by the project, as discussed in this paper, are also being widely used over the cane area. Continued research will, without question, develop many refinements and more effective and more economical methods.

The Structural Application of Glue in Framing Farm Buildings (Part III)

Effect of Dimensional Changes in Wood on Strength of Glued Joints

By Henry Giese and Elwin D. Palmer
FELLOW A.S.A.E.

WOOD has been the material most commonly used for framing farm buildings and will doubtless continue to occupy a prominent place in such use in the future. This has been due largely to its availability, comparative ease of fabrication and usually low cost. Results from its use, however, have not been universally satisfactory. Ease of fabrication encourages use by the relatively uninformed or unskilled with consequent frequent misuse. Adequate fastenings continue to be a problem in spite of recent radical improvements.

Early construction employed heavy timbers with little regard for efficient use. Recently, however, the trend has been toward plank frames using material usually 2-in nominal thickness. This has largely reduced the waste of timber framing but has introduced other problems. The joint has long been recognized as the weakest point in wood construction. For several years considerable attention has been given to the possibility of further improving the joints by the use of glue.

First application was made to the bent laminated barn rafter. This was a logical start because little hazard was involved in case of glue failure. Many rafters fastened by nails, bolts, or a combination of the two had given a fair degree of satisfaction. Glue appeared to offer considerable advantage in providing stiffness by preventing the laminations from slipping one over the other. In the case of a long, slender rafter, the maximum shear which could be developed, made only a small demand upon the glue. In case of complete glue failure, the rafter was not inferior to what it would have been had the glue been omitted entirely. Factory-made rafters, without bolts or nails, have now become standard commercial items.

The approach to this problem has been different if not diametrically opposite from the usual conception of glue research. Rather than seeking the proper specification for the making of a perfect glued joint, we have endeavored to ascertain the merits of joints which might be made on the farm either by the farmer himself or his carpenter, and then to write the specifications necessary to assure satisfactory performance under the conditions encountered.

At the outset, glue would appear to offer some very distinct advantages. Glued joints are not only strong but also very rigid. Nails possess little bearing area and hence begin to yield under small loads. Long before actual failure occurs, the nailed joint may be so deformed that the structure is badly out of shape. Other methods of fastening which are otherwise superior to nails, still possess this limiting feature to some extent at least. By the use of gusset plates if necessary, the area of glued joints can be increased to a size which will carry the applied loads adequately. Glue is easily applied and comparatively low in cost.

On the other hand, there are some potential limitations which have led to skepticism and perhaps to delay in the acceptance of glue as a fastener. The first of these is embodied in the glue itself. Until the development of modern glues, gluing farm structures was not feasible. Animal glues would soften and fail when exposed to humid atmospheres. The cost would likely be considered prohibitive. First of all, a glue must be highly water-resistant if not entirely waterproof. Casein glues are water resistant, perhaps even to as high a degree as the wood. Synthetic resin glues are available which are insoluble not only in water but also in most chemical solvents. Some of the latter, however, are not satisfactory for the purpose at hand because of other properties. A glue to be satisfactory, must remain sound in a thick joint which will result from the use of low pressures, such as would be provided by nailing, or the use of rough or poorly surfaced lumber.

When glued joints are made under controlled conditions, considerable attention is given to the making of a satisfactory surface. Dimension lumber when surfaced, is not planed as smoothly as the select grades. Native materials are likely to be rough sawn only. A number of the synthetic resin glues do not qualify in this respect. It is necessary also that the glues be susceptible to successful handling by relatively inexperienced users and at temperatures prevailing outside during the construction season.

The second potential limitation lies in the inherent properties of hygroscopic wood. The moisture content of wood varies with atmospheric temperature and humidity, thereby causing changes in not only the lineal dimension of wood across the grain, but also in what is termed warping.

Can a farmer be sure that joints made with glue will hold up over a period years? Is it advisable to use glue for joining wooden members as large as those used in framing farm buildings? Is it necessary to keep one of the glued members sufficiently thin that it will follow warping in the thicker one? These were some of the questions that had to be answered before farmers could be expected to make any appreciable use of glue in constructing their buildings.

The purpose of the study described in this paper was to investigate the effect of dimensional changes in the wood due to changes in moisture content, upon the strength and durability of the glued joint. Changes in the moisture content of wooden members joined with nails, bolts or timber connectors had little or no effect on the strength of the joint. However, when two wooden members of a given dimension are glued together, the hardened glue film that bonds them together resists any change in dimension of the members due to a change in their moisture content. This resisting force acts as a shearing stress on the glue line. It is conceivable that the change in moisture content could be of sufficient magnitude to cause failure of the joint if the resulting shearing stress reached the ultimate strength of either the glue or wood.

The Investigation. With a rise in temperature or a reduction in the relative humidity of the air, wood has a tendency to give up its moisture; whereas, with a drop in temperature or an increase in the relative humidity of the air, the same wood will absorb moisture from the air.

Climatic conditions vary so widely throughout the United States that the changes in moisture content of the wood will differ from place to place. The important factor in this study is not the differences that exist throughout the country, but the changes that occur at any given locality. A study of climatic conditions of the United States(12, 13)* reveals that

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*Numbers in parentheses refer to appended references.

though the moisture content of lumber in buildings may fluctuate between high and low several times during the year, it is always lowest in the summer months and highest in the winter months. So, generally speaking, the moisture content of lumber follows a yearly cycle, the range of which may vary from year to year.

The average range in wood moisture content in central Iowa is approximately from 12 per cent in summer to 16 per cent in winter.

Coast-type Douglas fir shrinks an average of 5.0 per cent radially and 7.8 per cent tangentially in drying from 24 per cent moisture content to oven dry(5). This means that under normal conditions in central Iowa, an 8-in flat grain board would be 0.1 in narrower in summer than in winter while the comparative change in an edge grain board would be about 0.064 in. The dimensional change parallel to the grain is so small that it is usually disregarded. When boards are glued with their grains parallel as in laminated rafters, the differences in dimensional changes resulting from angle of cutting are likely to be so small that no difficulty would be encountered. If they are glued at an angle, however, as they would be in braces, the stresses imposed upon the glue line might be sufficiently great as to result in damage.

Due to the fact that dimensional changes caused by variations in moisture content are not equal in all directions, the tendency of a flat-grain piece to warp would place a direct tension stress upon the glue line. The inherent weakness of wood in tension perpendicular to the grain might permit at least partial destruction of the joint.

Objectives of the Study. The specific objectives of this study were:

1 To determine the effect of expansion, contraction and warping on the strength and durability of glued joints of wooden members when the joints are made with grain of the members (other than parallel) at right angles.

2 To determine the relation between the thickness of the members and the loss of strength and durability of the joint.

3 To determine the relation between the width of the members and the loss of strength and durability of the joint.

4 To determine the value of sawing kerfs in the members prior to making the joint.

Method of Procedure. The glued joints tested in this study were made from No. 1 common Douglas fir lumber by using a resorcinol-resin glue. This glue was used because of its high resistance to moisture. Resorcinol-resin glue also has superior gap-filling qualities, making it less necessary for the members being glued to have smooth surfaces. It will set at low temperatures without the application of heat and requires little pressure during the curing period.

Lumber of dimensions commonly used in farm buildings, 1x4, 1x6, 1x8, 2x4, 2x6 and 2x8, was used (Figs. 1 and 2). Kerfs were sawn parallel to the grain and one-half the depth of the member in half of the joints made from the lumber of 2-in thickness. It was thought that these kerfs would greatly reduce the ability of the members to warp.

Pressure was applied on the glue line by 7d box nails at the rate of one nail for each 4 sq in of glue area.

The joints were subjected to a cycle of change in moisture content ranging from 9 to 19 per cent, which is 3 per cent below and above the extremes for a normal year and should allow for the most unusual years. The moisture content of the joints was changed by placing them in a controlled temperature and humidity room.

The effect of the changes in moisture content on the physical appearance of the joints is shown in Fig. 3. It is evident that the change in dimension of the members is resisted by the glue film between them. Splitting of the members occurs in the larger joints when the outer surface is free to shrink, but the surface adjacent to the film is restrained. A few of the wider joints showed evidence of wood failure at the edge of the glue line. Sections sawn through these joints revealed that the failure was only at the edges of the joints and did not extend far inward.

No change in the physical appearance of any of the joints made from lumber of 1-in thickness could be detected. The glue line of these joints remained intact and the members showed no evidence of warping or shrinking.

The joints were divided into four groups for testing as follows:

Group A made at 12 per cent moisture content and tested after a 14-day curing period

Group B made at a moisture content of 12 per cent, dried



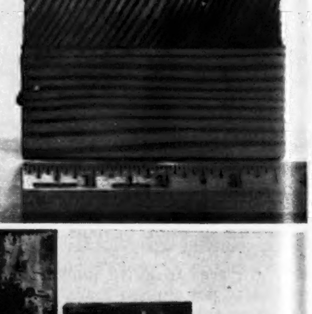
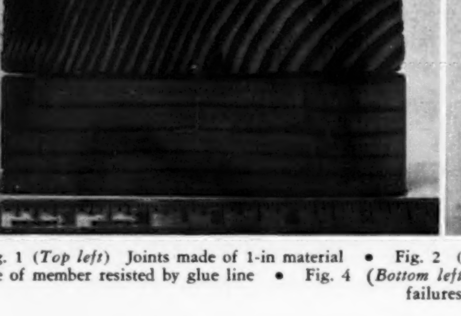
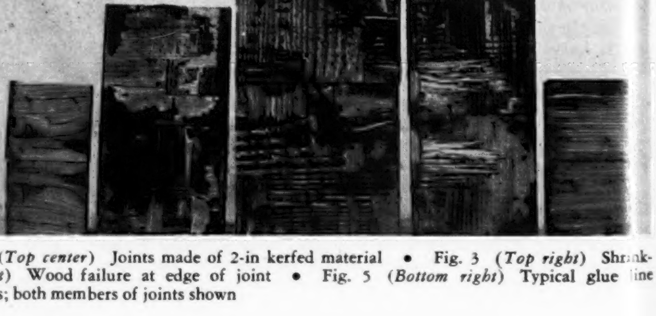

Fig. 1 (*Top left*) Joints made of 1-in material • Fig. 2 (*Top center*) Joints made of 2-in kerfed material • Fig. 3 (*Top right*) Shrinkage of member resisted by glue line • Fig. 4 (*Bottom left*) Wood failure at edge of joint • Fig. 5 (*Bottom right*) Typical glue line failures; both members of joints shown

to 9 per cent, raised to 19 per cent, and dried back to 12 per cent where the joints were tested

Group C carried through one complete cycle of change in moisture content as described in Group B above and then tested at 9 per cent moisture content

Group D carried through one and one-half cycles of change in moisture content and then tested at 19 per cent moisture content. Each group was identical and comprised a total of 90 joints. The following numbering system will serve to identify the joints in Table I:

The group letter A, B, C, or D

A numeral indicating the nominal thickness in inches of the lumber used for making the joint

A numeral indicating the nominal width in inches of the lumber used for making the joint

For joints whose members were kerfed, the letter "K" followed the width designation.

For example, a joint with the number B24K was made from 1x4 members which had kerfs sawn in them at the point of contact. This joint was subjected to one cycle of change in moisture content before being tested.

The joints were held in a jig which maintained alignment so that the load was applied parallel to the glue line and stressed to failure in a 60,000-lb Southwark-Emery testing machine. Results of the tests are given in Table I. Typical failures are shown in Fig. 5.

Compression failures in the wood stressed perpendicular to the grain prevented testing the 1x8-in joints without first cutting them into smaller joints. Results obtained cannot therefore be compared directly with the unit stresses obtained with the 1x4's and 1x6's.

Discussion. As noted in Table I, joints undergoing a change in moisture content showed a loss of strength. A cycle of change in moisture content appears to have no effect on the strength of glued joints so long as they are tested at the same moisture content at which they were made. However, joints made at 12 per cent moisture content and tested at 9 per cent or 19 per cent were somewhat weaker than the same type of joints tested at 12 per cent. The greatest loss for any particular size of joint was exhibited in the 2x8 joints. The 2x8 joints tested at 9 per cent moisture content were 27 per cent weaker than the average strength of all joints of this size tested at 12 per cent moisture content.

Table I

Shear Tests of Joints Subjected to Changes in Moisture Content

Type of Joint	Age of Joint	No. of Tests		Ult. Unit Stress psi Avg.	Range	Type of Failure
A14	14 da	12	2300	175	134-310	80% Wood
B14	60 da	10	2614	199	155-259	100% "
C14	81 da	10	2596	198	149-255	95% "
D14	102 da	9	2275	173	138-194	100% "
			Av. 2446			
A24	14 da	10	3371	257	187-359	90% "
B24	60 da	12	3143	239	171-322	95% "
C24	81 da	10	3227	246	172-368	100% "
D24	102 da	11	3260	249	202-297	100% "
			Av. 3250			
A24k	14 da	11	2250	192	158-249	95% "
B24k	60 da	11	2876	219	145-373	100% "
C24k	81 da	13	2973	226	154-300	95% "
D24k	102 da	12	2740	234	147-342	100% "
			Av. 2710			
A16	14 da	12	3727	118	75-163	80% "
B16	60 da	10	4244	134	101-164	85% "
C16	81 da	10	3203	101	89-122	80% "
D16	102 da	11	4244	134	107-166	85% "
			Av. 3855			
A26	14 da	12	6490	205	116-244	85% "
B26	60 da	10	5960	188	120-240	85% "
C26	81 da	10	4913	155	73-234	85% "
D26	102 da	10	5890	186	136-252	80% "
			Av. 5813			
A26k	14 da	10	4561	144	110-202	75% "
B26k	60 da	10	4571	145	111-221	65% "
C26k	81 da	10	3518	111	68-162	75% "
D26k	102 da	8	4490	142	102-184	70% "
			Av. 4285			
A18	14 da	10	11070	191	165-242	75% "
B18	60 da	10	12525	215	192-266	95% "
C18	81 da	10	10366	178	129-261	90% "
			Av 11320			
A28	14 da	9	7415	128	86-187	70% "
B28	60 da	12	8334	143	98-205	85% "
C28	81 da	10	5681	98	83-123	75% "
D28	102 da	5	7700	133	121-138	83% "
			Av. 7283			
A28k	14 da	11	5656	97	68-121	90% "
B28K	60 da	10	6499	112	72-137	90% "
C28K	81 da	10	5294	91	65-117	95% "
D28k	102 da	10	6499	112	91-140	100% "
			Av. 5987			

The strength of joints made from 4-in wide members was not noticeably affected by a change in moisture content. The difference in strength of the 1x4, 2x4 and 2x4 kerfed joints of groups A, B, C, and D is a normal variation. The joints made from lumber of 6 and 8 in widths showed a marked decrease in strength when tested at 9 per cent and 19 per cent moisture contents.

The joints made from 2-in thick lumber showed a slightly greater loss of strength due to a change in moisture content than those made from lumber of 1-in thickness. This was to be expected, since it is evident that a 2-in thick member exerts a greater force when it attempts to change dimension than a 1-in thick member.

In every case the joints that were made from kerfed members were weaker than those made from solid members. Loss in strength paralleled that in the solid members indicating that sawing kerfs did not accomplish its intended purpose.

When glued joints dry, the increase in strength of the wood tends to offset the loss in strength caused by the dimensional changes of the members. Theoretically, when the moisture content of a glued joint is increased, not only is the ultimate strength lowered because of the prestressed condition of the joint, but the wood also decreases in strength. This indicates that the joints tested at 9 per cent moisture content should be stronger than those tested at 19 per cent. Such was not the case, however.

The data obtained in this study indicate that the change in dimension due to a change in the moisture content of a glued joint is not great enough to impair the quality of the joint in any of the sizes studied. Slightly lower strengths were obtained at both extremes of the cycle of change in moisture content, but this was due to the prestressed condition of the joint. This loss of strength is not of sufficient magnitude to prohibit the use of glue in building construction, but some allowance should be made for it in determining a design stress to be used for glued joints.

CONCLUSIONS

1 Dimensional changes of the members of a glued joint occurring after the glue has become hardened are resisted by the glue line. The magnitude of the stress thus imposed on the glue line varies directly with the magnitude of the change in dimension. This stress subtracts from the ultimate strength of the joint.

2 The dimensional changes of lumber ranging up to 8 in in width and 2 in in thickness are not great enough to significantly impair the quality of glued joints.

3 Glued joints made from members with a width of 4 in at 12 per cent moisture content showed no appreciable loss in strength when tested at 9 per cent moisture contents.

4 Glued joints made from members of 6 and 8-in widths at 12 per cent moisture content showed a marked decrease in strength when tested at 9 per cent and 17 per cent moisture contents.

5 Strength of glued joints made from lumber of 2-in thickness is affected slightly more by changes in moisture content than the strength of joints made from 1-in thick lumber.

6 A cycle of change in moisture content has no apparent effect on the strength of glued joints if they are tested at the original moisture content.

7 Tensile stresses on the glue line caused by warping of the members are often great enough to cause partial failure of the wood fibers near the edges of glued joints made from 2x6 and 2x8 members. *(Continued on page 464)*

Cold Storage of Apples in the Pacific Northwest

By G. F. Sainsbury
MEMBER A.S.A.E.

IN THE fruit-producing areas of the Pacific Northwest adequate cold storage facilities are required as an integral part of producing and marketing an apple crop of 35,000,000 bu that comprises approximately one-third of the nation's production. Without cold storage it would be impossible to extend the marketing season over a sufficiently long period to dispose of the fruit in an orderly manner at a price which would return the farmer a profit on his investment, or even wages for his year's work. Without cold storage it would be impossible to supply apples in sufficiently good condition to justify sustained consumer demand throughout a season extending from September to July.

Concentration on Delicious apple production in the last 15 years has had a marked effect on cold storage design inasmuch as the fruit is harvested during the warmer weather, the crop comes in quickly imposing heavy receiving loads on both the cold storage and handling equipment, and prompt cooling to 30 to 32 F is absolutely essential to attain the maximum storage life of the fruit. The following tabulation shows the normal storage life expectancy of Delicious apples for continuous storage at various temperatures. Actually in commercial practice the fruit temperatures are not lowered to the desired temperature immediately and the second part of the table shows how different cooling rates modify the above figures on storage life. These figures also assume that the fruit has been picked at proper maturity and there has been no delay in storage. This is a very important factor since it has been found that one week of standing outside at 70 F will reduce the storage life approximately nine weeks, or one week at 53 F reduces storage life approximately one month.

TABLE 1 NORMAL STORAGE LIFE EXPECTANCY OF DELICIOUS APPLES*

Temperature, deg F		Days
Held at	70	20
	60	30
	50	50
	40	90
	36	130
	32	220
	30	280
Cooled to	30 in 7 days and held	250
	32 in 7 days and held	200
	36 in 7 days, then to 32 F in 4 weeks	180
	40 in 7 days, held at 40 F for 21 days, then cooled to 32 F in 28 more days	137
	36 in 7 days and held at 36 F	110
	36 in 6 weeks and held at 36 F	90

*Data is taken from USDA Circular 740 "Cold Storage for Apples and Pears" by W. V. Hukill and Edwin Smith, being based on information published in USDA Bulletin 1406, "The Ripening, Storage, and Handling of Apples" by J. R. Magness, H. C. Diehl and M. H. Haller.

In considering Table 1 it must also be remembered that these figures do not make allowance for time of transportation to market and distribution which operations necessarily are carried on at temperatures higher than optimum storage temperatures. Actually the fruit should be withdrawn from storage with sufficient storage life left to reach the consumer with good condition.

Sequence of Operation. The normal harvesting and handling operations consist of several distinct phases and each must receive proper consideration in a well-designed apple storage. The crop is normally picked either in the same boxes in which it will later be packed or in field lugs which are very close to the dimensions of the standard apple box. In most instances that portion of field boxes that cannot be handled at once by the packing line is placed in cold storage as it is hauled in from the field and segregation is made between different varieties brought in by a grower, and generally the different grower's fruit is kept separate. In some instances all of the fruit received from the field is placed in cold storage and allowed to cool prior to the packing operation. From the various segregations required and the fact that it is not uncommon to have 30 or 40 growers in a medium-size operation, it can be seen that the details of proper warehousing are an important consideration in the efficient operation of the cold storage plant.

In passing through the packing operation there is a reduction in space requirement as it takes about three field boxes to make up two packed boxes. Hence the maximum cold storage space requirement comes at the conclusion of the picking season and is dependent on the size of crop, rate of packing, and amount of fruit that can be profitably shipped to the early market and does not occupy cold storage space.

Cooling System Requirements. From the foregoing description of the sequence of operations in the typical packing and storage plant, it can be seen that, in addition to the normal sources of heat from wall transmission, air infiltration, men and machinery working in the storages, and electric lights, there are four special duties imposed upon the refrigeration system by these operations, as follows:

1 Cooling the loose product received from the orchard. Normal receiving temperatures will vary from 55 to 75 F depending on the season and the time at which the fruit is received.

2 Cooling the packed fruit which has traveled directly from the orchard to the packing line. This fruit will be as warm or possibly slightly warmer than loose fruit going into storage.

3 Cooling packed fruit which has previously been cooled in storage as loose fruit, but which warms appreciably during the time it is withdrawn from storage for packing. Such fruit returning to storage will normally range from 42 to 45 F.

4 Providing refrigeration to absorb the heat evolved by normal respiratory activities of the fruit in storage. Although this heat is a relatively small quantity per ton of fruit in storage, when the total amount of fruit is considered it becomes a substantial load that exists throughout the storage season.

Normally the first and second duty are concurrent and represent the period of maximum load which in many cases is four to five times the requirement of the plant when it is merely holding the storage load, or fourth duty.

The system should be arranged with flexibility to operate at partial capacity to meet the great load variation that is encountered in this type of application. To satisfy this requirement, the compressor capacity should be furnished by several machines, preferably of different size so that capacity to match the load can be selected by the plant operator or control system. Also in larger plants provision of independent evaporators for several sections of the storage is desirable because the loose fruit cools much faster than the packed fruit. Where they can be stored separately, it is usually possible to cool packed fruit faster by exposing it to lower air temperatures than would be possible if loose fruit were also stored in the same area.

Another requirement is that the system shall function with uniformity. A system where the refrigerating effect is not distributed uniformly will tend to freeze fruit in some areas, while furnishing other areas with insufficient refrigeration to maintain the fruit within the desired temperature range.

In storages cooled by convection from room coils adequate dispersion of the coils across the ceiling of the rooms plus proper arrangement of the coil circuits to secure some active

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coil surface in all portions of the room even at times when the coil feed has been restricted will generally promote uniformity within the storage. In many storages of this type auxiliary fans are used to assist in cooling the fruit and attaining uniform storage conditions.

In systems involving forced circulation from one or several air cooling units there are a number of factors involved in securing the desired degree of uniform temperature and rapid initial temperature reduction. First, there must be an adequate quantity of air circulated so that the rise in air temperature will not be excessive when the air absorbs the heat evolved from different sources in the refrigerated spaces. During extreme peak-load periods the temperature rise in the air will run from 7 to 10 deg and during the storage period it will generally be in the order of 2 to 3 deg.

The manner in which the air is distributed will have an effect on the uniformity of storage temperatures; non-uniform distribution of air is simply non-uniform distribution of refrigeration. After the distribution system has been installed it must be carefully adjusted and balanced to secure uniform distribution. Although duct sizes and openings may have been carefully engineered, there is no substitute for final adjustment in securing uniform distribution.

It is possible to produce a smaller temperature variation in the fruit in the room than occurs in the air passing through the room by either of two methods. Either the air can be supplied to the room in such a manner as to aspirate a large percentage of room air into air streams and temper the cold air before it starts its passage through the fruit and in effect amounts to the circulation of a larger quantity of air through the fruit; or the direction of air flow may be periodically reversed so that the fruit that is in the extreme positions in the room is alternately exposed to warm and cold air. When the cycles are made on a one-hour interval there is sufficient lag in the fruit to maintain a reasonably uniform median temperature. Where a single direction distribution system with a little provision for aspirating secondary air is used, about the best that can be expected is to have the variation in fruit temperature approximate the rise in air temperature as it passes through the room.

In addition to having the air properly distributed, it is also necessary to have the fruit properly arranged so the air can circulate through it to best advantage. Air circulation should be parallel to the stack rows wherever possible as tests have shown a definite advantage for this arrangement as compared to rooms where stacks were perpendicular or at odd angles to air flow. Also careful and regular stacking with attention to maintaining a continuous space between rows will promote uniform conditions.

Where fruit is held in rooms on ground floors, it is recommended that some form of rack be used to allow air to pass beneath the stacks and pick up the heat transmitted from the ground before it is transmitted into the fruit. Even where floors are well insulated in accordance with the standard recommendations for this type of service, this transmission is appreciable and fruit stacked directly on such floors will have a temperature in the bottom layer of the bottom box approximately 1½ deg higher than the average temperature of the upper boxes in the stack. With poorly insulated or uninsulated floors this differential will be in the order of 3 and 4 deg.

The rate of cooling of the fruit will be influenced by the air velocity through the stacks of fruit. If air is introduced at a great number of places in the room only to travel a short distance to a return opening, the velocity will necessarily be less than if a longer path of travel is arranged for all of the air circulated. At the same time a short travel path will not mean a small rise in air temperature because the rise in air temperature is determined by the total heat load to be absorbed and the total quantity of air circulated. Air velocity through the stacks can also be increased by the aspiration of large quantities of room air into the primary air supply as the air leaves the supply openings. The increase in velocity in this case is due simply to the fact that there is more air moving through a given space.

Where cold diffusers are equipped with outlet cowls for air distribution, the cowl arrangement should be designed to suit the particular room; air should be discharged high enough so it will not blow directly on the fruit in front of the unit and have its travel restricted; also the discharge should be arranged so that all portions of the room are covered equally.

With some commodities rapid air motion, even at high relative humidities, may lead to excessive dehydration; however, with the apples grown in the Pacific Northwest and protected by wraps and liners, dehydration due to the velocities encountered in the rooms has not been a major problem so long as the relative humidity is maintained from 80 to 85 per cent. Normal velocities between stacks in storage rooms will be in the order of 50 to 70 fpm, and even in rooms with extreme air motion the velocities are rarely more than twice the above.

Types of Refrigeration Apparatus Used. The cold storage plants in the area provide a remarkable variety of equipment arrangement and application detail. A few of these plants have sections dating back 35 yr, and all stages of development between that time and the present are to be found. For the most part reciprocating ammonia compression systems are used. Both vertical and horizontal compressors are to be found in the older plants, but the vertical machine arranged for automatic starting has practically eliminated the horizontal compressor in the newer plants. In small storages small Freon-12 compressors are being used to some extent.

Where adequate well or river water is available, closed horizontal shell and tube condensers are most generally used; however, where adequate water supply is not available, evaporative-type condensers have come into general use, supplanting spray pond or cooling tower and condenser combinations.

Originally most plants were equipped with room coils, hung overhead and along the sidewalls, cooled by the direct expansion of the ammonia refrigerant. Where such plants were adequately piped, the coils well arranged and auxiliary fans provided to give proper air circulation, good results can be obtained, although the coils and drip pans constitute a substantial space requirement and also represent an added load which the building structure must support. Plugged and frozen gutters from drip pans may allow water to run on the stored products and floors, seeping into the insulation and eventually leading to rotten timbers.

To alleviate some of these problems, it later became the practice to place the 2-in pipe coils in a bunker room and blow air over them and deliver the cold air to the storage rooms through ductwork. A great number of these plants suffered from inadequate air-circulating capacity and also rapid loss of capacity due to frost accumulation. Defrosting arrangements were cumbersome and the refrigerant charge was large, making such plants difficult to operate.

The brine-spray air washer was evolved to overcome the defrosting difficulties of the dry coil bunker. In this system the air is passed through a chamber where a large quantity of brine is sprayed from a system of nozzles arranged so that all of the air passing through the chamber comes in contact with this fine spray and is cooled by the chilled brine. The brine is then cooled by coils containing ammonia refrigerant. These coils may either be placed in the air stream following the sprays or may be submerged in the tank of the air washer or in a separate tank. Placing the coils in the air stream is the general present-day practice as a very high heat transfer is secured with the brine running down over the coils and only about one-third as much coil is required as in the submerged coil arrangement. Sodium chloride brine is normally used in apple-storage installations. A variation of this system is the wetted surface unit where a small quantity of brine is sprayed on the cooling surface to prevent frost accumulation.

To eliminate corrosion and the power to operate the brine pumps that are required with the brine spray system, there has recently been some trend to return to a more modern version of the dry coil bunker system. In these instances finned coils are used so that a large cooling surface can be obtained at moderate cost and arranged in a compact manner. Also, the coil volume is greatly reduced as compared with the old bunker system decreasing the refrigerant charge and simplifying coil feeding and control. It is normal to provide

these systems with an automatic intermittent warm water defrosting arrangement operating every 3 or 4 hr. Water is heated during the operating period by taking heat from the compressor discharge gas to heat the water in a large sump. At the defrost period the compressors are stopped and water is pumped from this sump over the coils and returns to the sump for about a 15-min period.

This type of system may take the form of individual room cold diffusers or a large coil bank with a fan to circulate the air to the rooms through a duct system.

Satisfactory results have been obtained with this system particularly in applications not subjected to excessive receiving loads during the warmest part of the season when moisture pickup is extreme. Where conditions involving heavy moisture loads exist, the use of a non-frosting-type evaporator is still generally preferred.

In recent years more attention has been given to air-distribution systems than heretofore and reversing systems and high-aspirating systems have been developed and applied to many installations. A growing realization of the importance of uniform fruit temperatures in the storage will give continued emphasis on air distribution.

Storage Construction. Storage construction methods display a tendency toward the use of native materials whenever such use is economical and practical. Although building walls are generally reinforced concrete or concrete-block construction, thereis a far greater use of wood construction for the interior framing than is normal in other sections. Walls are often insulated with a 12-in shaving fill retained between the outer concrete wall and an interior wood wall. In the period following the war the increasing cost of lumber and carpenter labor brought the cost up to where board-form insulation set in hot asphalt could compete with shaving-fill walls and many plants constructed in that period had the most conventional type of insulation. Most storages are constructed with an attic space and with 18 to 30 in of shavings blown in above the ceiling. A variety of practices exist regarding floor insulation, and in some cases where favorable dry soil conditions prevail, ground floors are uninsulated. As previously pointed out, ground floors should be provided with floor racks. Pumice, which is available in many localities, is often used for basement-floor insulation. Cinders and coke fines also are similarly used. For best results a waterproof membrane, usually heavy asphalt roofing, should be provided between the earth and fill insulations of the above type. Vermiculite, or expanded mica, which is produced in the Pacific Northwest, also has had some use as an insulator; however, it has a high moisture absorbing capacity and where used it should be carefully sealed against moisture infiltration. Use of this material in lightweight concrete mixtures for insulating purposes has been tried with various results. If the mixture is made with an excess of water, final drying of insulation is extremely slow with consequent reduction of insulation value during this period.

Because local materials have been generally used in the insulation of these buildings, and such materials have been cheap, there has been a general practice to insulate these storages more heavily than is the standard for the temperatures

(Continued on page 462)

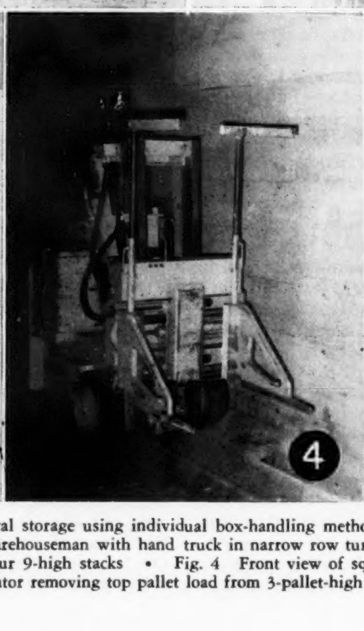
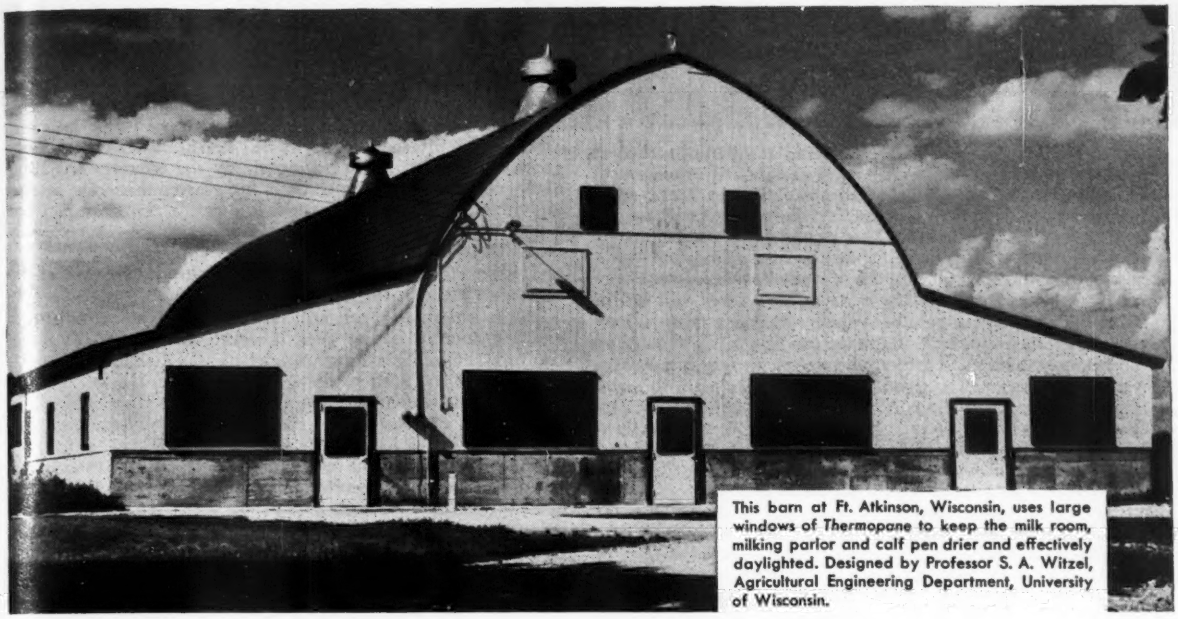


Fig. 1 Apples high piled in field boxes in typical storage using individual box-handling methods. Belt conveyor in the foreground • Fig. 2 Packed boxes high piled in the same storage. Warehouseman with hand truck in narrow row turning stack to wheel it out to conveyor • Fig. 3 Squeeze truck picking up top five boxes from four 9-high stacks • Fig. 4 Front view of squeeze truck without load • Fig. 5 Fork truck operator removing top pallet load from 3-pallet-high stack



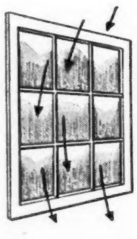
This barn at Ft. Atkinson, Wisconsin, uses large windows of Thermopane to keep the milk room, milking parlor and calf pen drier and effectively daylighted. Designed by Professor S. A. Witzel, Agricultural Engineering Department, University of Wisconsin.

How Insulating Glass Improves Ventilating Efficiency

IN FARM STRUCTURES

Whether a farm structure is designed for gravity ventilation or mechanical ventilation, cold window surfaces can disturb the planned air flow and the effectiveness of the system.

THE PROBLEM results from two causes:



1. Convection currents occur at the windows to disturb and divert the flow of air.

2. Air contacting the cold window surface is thereby cooled. Condensation forms on cold window surfaces. Thus, this moisture is deposited within the structure rather than carried away. Convection currents having been cooled are less able to carry away moisture, and thus fail in one of the important functions of ventilation.

The result of this situation is a colder, damper building—a condition harmful to poultry and livestock health and production.

THERMOPANE IMPROVES VENTILATION— aids moisture control. *Thermopane** insulating glass is made of two panes, with dry air hermetically sealed between them. This blanket of air keeps the inner pane warmer. Thus, drafts are reduced, chilling of air at the windows is considerably diminished, and condensation on glass areas is minimized. Result: warmer, drier conditions for healthier poultry and livestock—more comfort for people who work in those buildings.

Many other benefits are derived from the use of *Thermopane*. It enables you to use larger glass areas for the solar heating and germicidal benefits of sunlight without fear of excessive heat loss during low outdoor temperatures. More uniform indoor temperatures can be maintained. Reduction of condensation on windows means longer life for window frames and the barn structure. Drier windows stay cleaner, gather less dust and bacteria.

Thermopane may be installed in fixed sash or in ventilating types of sash. Generally, it is wise to choose windows with large glass areas, free from light-robbing and dirt-catching cross members. *Thermopane* is made in a wide range of sizes—in plate glass for use where clear visibility is required (such as home picture windows) and in more economical sheet glass where large glass areas are desired but where appearance is not of prime importance.

Thermopane is sold by glass and building supply distributors and dealers. Write for our *Thermopane* folder and for suggested installation procedure. And feel free to write us on any problems in glazing farm buildings.

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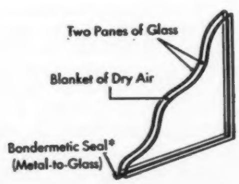

Cold Storage of Apples

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involved. For instance, it is considered standard practice to insulate 30-deg storages with 4 in of cork-board insulation or its equivalent. The normal wall insulation in these apple storages, 12 in of shavings, is conservatively considered equivalent to 6 in of cork board. This practice has contributed to economy of operation by reducing the heat gain from transmission and thereby reducing the operation of the compressors. Also the better insulated the storage, the slower will be the changes of inside temperature when conditions outside have changed; thus uniformity of storage conditions is promoted by the better insulation. Further, the degree to which a storage is insulated has an effect upon the ability of the plant to maintain the desired humidity. Although this is rather a complex relationship, in generalties it can be considered in the following manner. In practical operation the evaporator of the refrigeration system will extract some moisture from the air at the same time it absorbs the sensible heat load by reducing the air temperature. The amount of moisture that is available for extraction without dropping the relative humidity in the storage below the desired point is dependent upon a number of factors such as quantity of fruit in the room, air infiltration, number of men working in the room, but for each case there is a certain definite amount of moisture available. It then follows that the lower the heat gain from transmission through the insulation (and this is the major source of heat gain during the latter part of the storage when humidity is a critical matter), the more moisture there will be available in proportion to the sensible cooling work that must be performed, and the chances are greater that the evaporator will perform the required sensible cooling without bringing the relative humidity lower than required.

Handling Methods. Reference has been made previously to the importance of handling procedures in the cold storage, and some effort has been made to outline the various handling problems; however, a more detailed description of handling methods is in order because in the last 4 or 5 yr there have been introduced innovations in handling that have required major changes in construction practices and refrigeration application details. These changes have been caused by the introduction of palletized methods of handling.

Previous to the introduction of palletized handling, the handling of individual boxes had developed certain techniques, and structures to suit these techniques had become standardized to a degree. Because the average storage constructed for the older methods of handling is not usually well suited to pallet operation, the older methods continue in use in existing plants. In these plants long-distance movement of fruit is usually made on belt conveyors, whereas shorter movements of fruit are made by hand trucks conveying single stacks of fruit 5 or 6 boxes high. About 100 ft is the maximum economical trucking radius, and belt conveyors are generally arranged through the storages to bring all parts of the storage within this range of the belts. The belts can go from one level to another on about a 15-deg slope, and in most plants they are arranged to perform the function of elevators, although some plants also have elevators installed for handling stacks of fruit from floor to floor. Most plants constructed for this type of handling were multistory buildings, generally two or three floors. Ceiling heights vary and in some cases fruit will be stacked 12 to 15 boxes high by crews putting up each box individually. In other cases the ceiling is such as to accommodate stacks only eight boxes high which can be stacked by one man working from the floor.

In handling fruit with the pallet system, the boxes are stacked on pallets when they are loaded aboard the truck at the orchard to be hauled to the warehouse. The pallet sizes vary, but a pallet accommodating 40 boxes arranged 2 wide, 4 long, and 5 high is a common size. A normal truck load is 6 pallets. Upon arriving at the storage plant, the truck is quickly unloaded by men operating power-driven fork-lift trucks capable of handling 3,000 to 4,000-lb loads. If this loose fruit is going into storage, the fork truck will proceed into the storage with its load and deposit it in the proper row in the storage. The storage height is usually such that the fruit is stacked three pallet loads high and the fork trucks are arranged to lift their loads to this height. Because of their greater speed and load-carrying ability the economical radius of operation of the fork truck is far greater than that of the individual hand truck. Because it is a simple matter to pick up a load and move it around as desired, during peak receiving hours fruit may be set to one side on the unloading apron, and when the rush is over can be taken inside and stacked in its proper place in the cold storage.

Most pallet storages are single-story plants constructed with the floor at ground level; however, there have been some two-level buildings constructed where the building site was on a sidehill and both levels were accessible to trucks. In such plants an elevator will generally be required for conveying pallet loads of fruit and occasionally fork trucks from one level to the other.

The "squeeze" truck is a modification of the fork truck that has recently come into use in the district. Although there has not yet been enough experience with this apparatus to definitely determine its proper place in the handling picture, it appears to offer some promise. This apparatus has a hoisting mechanism similar to the fork truck, but instead of having forks which reach in under a pallet, it has on each side at the floor clamp arms fitted with a number of spring-loaded grips. The clamp arms can be moved in and out by a hydraulic mechanism. When picking up a group of stacks, the operator lowers the clamp arms to the floor level and then uses them to squeeze the stacks together until they are firmly gripped; then he can lift the stacks and travel with them in the same manner as the fork truck. The squeeze truck is available in two sizes, one to handle 8 stacks and the other to handle 4 stacks. The smaller machine is lighter and more maneuverable and has been developed for use in existing buildings where the concentrated floor loads imposed by the conventional fork truck and the larger squeeze machine were prohibitive.

Comparison of the Various Methods. A comparison of methods shows that each has certain advantages that must be considered in evaluating the methods.

The individual-box method of handling has considerable advantage in the flexibility of segregating packed fruit, where segregation is a substantial problem. To handle the same degree of segregation with a pallet operation will require four to six times as much space, and where there are many small lots, warehousing these so they are accessible becomes troublesome. On the other hand, it must be noted that with the fork trucks and pallets it is much simpler to "dig out" hidden lots than in the individual box operation. With the individual-box system the investment in pallets, handling and keeping track of them is eliminated, likewise investment in and maintenance of fork trucks is avoided, although the belt-conveyor systems represent an investment that offsets this to some extent. Also, with the individual box system, entrance to the cold storage is made through smaller openings with the result that refrigeration requirements to counteract air infiltration are considerably less than with the pallet storage. Also, the fork trucks give off some heat that must be removed by the refrigeration system. The door loss can be restricted by the use of automatic or semiautomatic power-operated doors at the entrance of the pallet storages, but these represent an investment which can properly be charged again the pallet operation.

The pallet system has a particular advantage in smoother handling of the fruit. With the individual-box method each box is picked up and set down many times in the course of its travels through the warehouse and there is usually some roughness attending this operation. The fork trucks start and stop their raising and lowering operations more smoothly and the box receives individual handling about four times in the process from orchard to railroad car. Careful studies have shown pallet handling in the loose-fruit operation produces only 61 per-cent of the bruising observed with hand methods.

Because unloading from growers trucks can be accomplished more readily there is less time spent by growers wait-

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Cold Storage of Apples

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ing in line to be unloaded at the cold storages. This represents an important wage saving to the grower and enables him to do more work with his truck investment.

The original object of palletizing was to lower the handling costs and operators report much lower costs; however, an unbiased study of two operations that are sufficiently similar that they can be compared has not been made taking into account all the factors of investment and maintenance, as well as direct labor. Such a study would probably show that there is not as much saving in operation as is generally supposed, because the investment costs are considerable.

To give a general idea of what can be accomplished during the receiving season with the pallet operation, the following operating experiences are cited.

One large cooperative organization operates a plant consisting of two large storages at one location. The older storage is a typical plant handling fruit by the individual-box method; the newer plant is a palletized operation. In a normal day's operation a crew of 18 men in the old plant can receive and put away 15,000 loose boxes. In the new plant, a crew of four men with fork trucks can receive and place in storage 32,000 loose boxes.

In another case an operator of a 160-carload-capacity storage and packing plant was able to operate during the receiving season with three fork truck operators who warehoused all the loose and packed fruit, supplied the packing line with fruit, removed the segregated packed fruit from the man doing the segregating and handled the miscellaneous supplies required by the packing room and loose boxes and pallets required by the grower. On peak days this handling crew would work 11 hours per day and in that time would receive 11,000 to 13,000 loose boxes and place in storage 1,500 to 2,000 packed boxes of apples.

In connection with pallet storages there is some saving possible in building construction because intermediate floor structures are eliminated; however, there is a tendency to absorb the amount saved on the building by paving exterior areas to give more flexible handling.

Also the pallet operation has the advantage that the pallet on the floor is in reality a portable floor rack and is of value in eliminating the transmission of ground heat into the fruit.

Although the use of squeeze trucks is still in the experimental stage, they are of interest because they offer the following advantages.

The investment, handling, and accounting for pallets is eliminated.

The truck can handle single stacks as well as double-stack loads and can pick off any number of the upper boxes of a stack the operator may select. This is an advantage in combining partial loads and in high stacking where ceiling heights, for instance, permit a 9-box high stack and the full stacks coming from the orchard truck are 6 high.

The truck is useful for handling other commodities around the plant such as empty boxes, cull fruit, paper and packing supplies—all commodities that are bulky and where it is not desirable to tie up pallets.

The squeeze truck has the serious disadvantage that it must pick up its load from a surface that is level with respect to the transverse axis of the machine. It cannot satisfactorily pick up its load from the side of a motor truck because the truck bed is rarely level. With the pallet truck operating under these conditions, the pallet is leveled as it is picked up, but with the squeeze truck the pile is firmly grasped before being picked up and cannot be leveled.

Special Requirements of Pallet Storages. Although the extent of savings in operating cost with the pallet storage is difficult to analyze, its additional advantages from the standpoint of smoother and more rapid handling are sufficient to lead to the belief that most large future construction will be of this type. The squeeze truck will probably find its largest application in existing warehouses.

Since palletized storage is a recent innovation, the following special requirements for this type of plant should be noted.

In general, single floor construction on ground level is used; where topography or land values make multilevel buildings advisable, the floors on upper levels must be heavily reinforced.

The storages should be constructed with as few columns as possible as these interfere considerably with stacking in the storage. In single story buildings up to 100 ft wide it is customary to use roof trusses and eliminate all columns.

Entrances to the storages should have adequate clearance for passage of the trucks. It is good practice to make the openings two or three feet wider than the pallet load to assure clearance. Special automatic or semi-automatic power-operated sliding doors should be installed back of the cold storage doors so that the storage can be closed except for those short intervals when the truck is actually passing through. If such doors are not provided the cold storage doors will be open for most of the 8-hr period that the receiving crew works.

Large exterior paved areas slightly lower than the cold storage floor are required for proper handling in connection with this type of operation. A portion of these should be covered so that during winter weather handling operations that are best carried on outside can be accomplished conveniently.

Electric-driven trucks are preferred for use inside cold storage, in spite of the inconvenience of charging their storage batteries and the higher first cost of apparatus. Gasoline-engine-driven trucks will soon load the storage with fumes to a point where they are obnoxious and dangerous if the storage remains closed during the period of their use. Such trucks are very useful to handle work outside of the storage and can be used for an occasional trip into the storage; as a result it is common to see both electric and gasoline trucks at a plant with the gasoline trucks working outside most of the time.

Glue in Framing Farm Buildings

(Continued from page 457)

8 Kerfing of members to be glued has little value in minimizing the effect of dimensional changes of lumber.

9 Nailed and glued joints after being stressed to failure will still carry a greater load than nailed joints due to the frictional resistance of distorted wood fibers in the plane of failure.

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Technical Aspects of the USDA Watershed Program for the Missouri Basin

By L. L. Kelly
MEMBER A.S.A.E.

ABOUT three years ago, President Truman, in a message to the Congress, declared that "the major opportunity to increase the wealth of the Nation lies in the development of the great river systems." I can find no better example of this statement than the great basin of the Missouri River — the country's largest single river. Its waters flow from ten states and drain one-sixth of the country's total land area, one-fourth of its farm land. Its waters are gathered by 80,000 miles of tributary streams with drainage areas of less than 250 square miles and 20,000 miles of streams with drainage areas of over 250 square miles.

In October, 1949, the U. S. Department of Agriculture recommended to Congress an agricultural program for the Missouri Basin for the development and conservation of land, water, and forest resources, and for flood control. The program encompasses five major operating phases:

1 Conservation and improvement measures on crop and grass land.

2 The development and management and use of forests and ranges

3 Stabilizing measures for small watercourses

4 Irrigation

5 Drainage.

Supporting these primary phases are (a) soil surveys, (b) research and investigations, (c) extension education, (d) credit, and (e) rural electrification.

The proposed Missouri Basin Agricultural Program will not replace the existing agricultural programs. Programs of assistance to landowners and operators, work on public lands under jurisdiction of the Department of Agriculture, and other cooperative work will continue as provided for by allocations from existing national agricultural programs.

In addition to the continuation of existing programs throughout the Basin, it is anticipated that the first stages of acceleration and intensification will be carried out in areas of highest priority. These high priority areas will in general include the areas where, first, flood and sediment damages and erosion losses are greatest, and where, second, the combination of interrelated land use and conservation practices and measures for stabilizing small watercourses will produce the greatest benefits. This requires the application of the measures on a subwatershed basis.

The design and application of a program on a subwatershed must make use of the best thinking of engineers, hydrologists, sedimentationists, agronomists, range specialists, foresters, soil technicians, and economists. These men must think not only along the line of their specialty, but their thinking must be guided by consideration of the habits, customs, resources, and abilities of the people in the subwatershed.

In connection with the development of the agricultural program for the Missouri Basin, the Soil Conservation Service made intensive studies of several subwatersheds. The purposes of the studies were to determine a complete program of conservation measures and stabilizing measures for small water courses, and to analyze the effectiveness of this program in reducing damages caused by floodwater, sediment, and erosion.

The small watersheds ranged in size from 5 square miles to about 250 square miles, and in geographical location from eastern Kansas to central Montana. They represented a wide range of conditions and presented typical local problems.

This paper was presented at the winter meeting of the American Society of Agricultural Engineers at Chicago, Ill., December 1949, as a contribution of the Soil and Water Division.

The author: L. L. KELLY, flood control specialist, Regional Water-Conservation Div., Soil Conservation Service, U. S. Department of Agriculture, Lincoln, Neb.

The studies centered around (a) an inventory of damages caused by floodwater, sediment, and erosion, (b) the planning and selection of a program to alleviate the damages, and (c) the evaluation of the effects of the program on damages, i.e., the benefits.

The inventory of damages included the damage to crops and pastures by floodwater and sediment, the damages to land such as streambank erosion, gullying and valley trenching, the damage to farm improvements, and the damage to roads, bridges, railroads, and utilities. These damages were inventoried physically and then evaluated in terms of dollars.

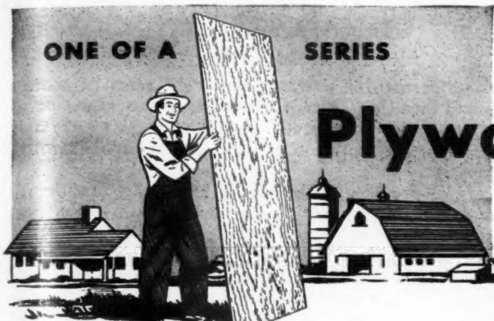
The planning and selection of a program included consideration of agronomic land treatment measures such as the maintenance of cover, use of soil amendments, crop rotations, pasture and range management, and changes in land use based on land use capability classes; it included consideration of mechanical land treatment measures such as terraces and contouring; it included consideration of structural measures such as gradient control structures, retarding dams, and floodways.

The evaluation of the benefits of the program consisted of determining the effect that the designed program would have on the reduction of the damages mentioned above, plus the conservation benefit that would accrue to farmers and ranchers from increased crop yields. It is important to recognize that conservation measures almost always increase crop yields.

In working with the three elements of damages, program, and benefits, there were many problems. There is, for example, a great lack of hydrologic data for small watersheds; the relationship of floodwater to crop and other damage is indefinite because of many variable factors; the effect of conservation measures upon crop yields is not readily determinable, particularly when several measures are used in combination. These are problems that had to be met by individual technicians and in consultation with residents of the watershed and authorities in the several fields. A more difficult problem was to achieve an understanding of the interrelationship of measures and the different effects various combinations of measures would have.

To gain understanding of the interrelationship of measures, and of the relationships of benefits and costs of combinations of measures, several alternative programs were considered for each of the small watersheds. These alternatives ranged from providing significant protection by use of land-treatment measures alone to providing protection by the use of land treatment plus a maximum use of structural measures. A program depending on land treatment alone resulted, in most cases, in large reductions in acreage of cultivated cropland and consequent drastic changes in the farming systems that were not believed practicable of attainment. Land treatment plus intensive measures for waterway control improves and maintains the watershed but frequently results in excessive costs. Somewhere between these two extremes there are practical, sound solutions to the floodwater, sediment, and erosion problems of the subwatersheds.

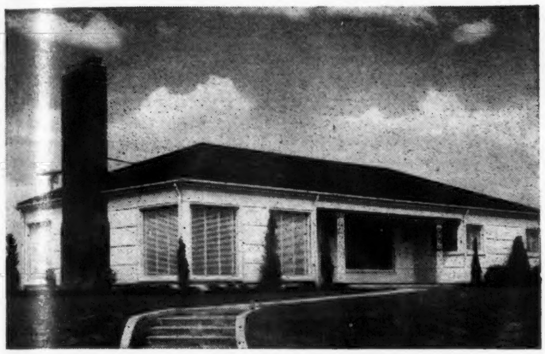
We realized that a program could not be planned piecemeal. The land-use treatment planned by the land conservationist must tie to the structural measures planned by conservation engineers (Table 1). For example, crop rotations, fertilizers, etc., are commonly accepted conservation practices. This type of measure reduces damage by protecting the land from sheet erosion, and increases infiltration by protecting the soil surface and promoting better soil structure. However, on certain land types these measures cannot stand alone. Terracing is required. The terraces will decrease sheet and gully erosion and thus support the above measures by maintaining the fertility and soil structure. (Continued on page 4[illegible]8)



Plywood on the Farm

...for Home Construction

STRENGTH, durability, rigidity, ease of handling and workability—these are the primary advantages of Douglas fir plywood for home construction. Versatile plywood may be utilized through every step of home building:



A charming modern home of Douglas fir plywood

Basement, Foundation Forms: Specify PlyScord for quickly-constructed "one-use" concrete forms. Panels are easily stripped for economical re-use as sheathing or subflooring.

Subfloors: Use PlyScord for rigid, tight construction. Provides a superior platform for finish flooring, gives extra lateral rigidity against wind and earthquakes.

Underlay Floors: Under linoleum, composition tiles, carpeting and other wall-to-wall coverings, specify PlyPanel or PlyBase. Big panels give a smooth surface, with very few joints to offer points of wear.

Wall Sheathing: PlyScord adds strength, rigidity and tightness. Government tests show plywood sheathed walls to be more than twice as strong and rigid as 1 x 8" diagonally sheathed walls.

Roof Decking: PlyScord means tighter construction here, too, and a superior deck for shingles or other finish roofing.

Exterior Walls: PlyShield fits any architectural treatment. Can be used for lapped siding, wide siding, board and batten, flush surfaces. Preferred for gable ends, dormers, soffits, porch ceilings, trim.

Interior Walls: PlyPanel provides attractive, kick-proof, puncture-proof walls, partitions, ceilings. May be given light stain-glaze finish to bring out the natural wood beauty . . . painted, enameled or papered. With plywood "dri-bilt" construction there is no dry-out period to postpone home occupancy.

Cabinets, Built-Ins: Several grades of Interior-type plywood may be utilized for kitchen and bathroom cabinets, wardrobes and other built-ins. Further details on plywood for this use—and other construction uses throughout the farm home—will be found in the booklet offered below.

EXTERIOR-TYPE Douglas Fir Plywood PLYSHIELD GRADE A-C DFPA INSPECTED EXT-DFPA

PlyShield is the siding grade of Douglas fir plywood. This is a grade within Exterior-type plywood; panels are bonded with completely waterproof adhesive, and identified by the EXT-DFPA grade-trademark (see below). One face of highest appearance quality; sanded both sides.

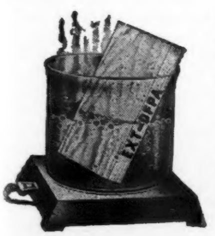
INTERIOR-TYPE GENUINE Douglas Fir Plywood PLYSCORD GRADE C-D SHEATHING D.F.P.A. INSPECTED

PlyScord is the unsanded construction panel, for sheathing, subflooring and roof decking on farm homes. Bonded with highly moisture-resistant (but NOT waterproof) glues.

Douglas Fir Plywood PLYPANEL GRADE A-D INTERIOR-TYPE D.F.P.A. INSPECTED

PlyPanel is the "one-side" grade of Interior plywood, with face of highest appearance quality. Sanded both sides. Bonded with highly moisture-resistant (but NOT waterproof) glues.

For ALL Farm Service Buildings, Specify Exterior-Type Plywood!



For BOTH exteriors and interiors of service structures—barns, poultry houses, etc.—specify Exterior plywood only. The 100% waterproof bond of Exterior plywood will withstand hours in boiling water—a test more severe than years of weathering. The EXT-DFPA grade-trademark on the panel edge is your positive identification.

Complete data on plywood's farm uses—including farm home construction—is contained in this 28-page booklet. Single copies free to Agricultural Engineers and Specialists. Write the Douglas Fir Plywood Association, Tacoma Bldg., Tacoma 2, Wash or Albert E. Powell, Agricultural Engineer, P.O. Box 32, Ames, Iowa.

Get This Booklet

Douglas Fir Plywood

AMERICA'S BUSIEST BUILDING MATERIAL

Watershed Program for the Missouri Basin

(Continued from page 466)

Terraces require vegetative outlets, in fact, the terraces are dependent on the vegetative outlet.

The vegetative outlet in many cases is not a complete answer to the control needs and grade stabilization structures are required to support the vegetative outlet. Thus all of the measures above become dependent on the grade stabilization structure. In correct combination this group of measures will reduce erosion on the land and in minor waterways to a practical minimum; thus downstream sediment damage will be significantly reduced. In contrast, the effect of these measures upon runoff reduction may be relatively minor in a large part of the Missouri Basin. Climatic effects on vegetation, and the reluctance of individuals to exchange cash crops for runoff-reducing crops will make the runoff reductions extremely variable. Additional measures that will complete a balanced program for the reduction of floodwater, sediment, and erosion damages should be considered. An example of such a measure is a retarding dam. Retarding dams will cause an immediate and positive reduction of downstream damages. In numerous cases they may be substituted for gradient control structures at a reduced cost; and in many cases they will reduce the cost of grade stabilization structures and other measures by controlling the inflows to the measure below.

TABLE 1. INTERDEPENDENCY OF MEASURES

Measure	*Effect*
Crop rotations,fertilizer, etc.	Reduces erosion, increases infiltration
Terraces	Maintains soil structure and fertility by decreasing sheet and gully erosion
Vegetative outlets	Supports terraces
Grade stabilization structures	Supports vegetative outlet
In combination, the above measures reduce downstream sediment drainage significantly; however, the reduction of downstream floodwater damage is minor.	
Retarding dams	Reduces downstream floodwater damage; reduces costs of other measures by reducing peak discharges; may be substituted for grade stabilization structures at a lower cost

In all of the small watershed studies an analysis was made of the costs and effects of three or more alternative programs for the reduction of floodwater and sediment damages. A simplified analysis of the programs on one of the small watersheds is presented in Table 2.

TABLE 2. SIMPLIFIED ANALYSIS OF ALTERNATIVE PROGRAMS FOR REDUCTION OF FLOODWATER, SEDIMENT, AND EROSION DAMAGE

Program	Land treatment: Reduction in cropland, per cent	Land treatment: Mechanical tillage practices, acres	Structures: Grade control	Structures: Retarding dams	Reduction in damage per cent	Annual costs, $1,000	Net annual benefit, $1,000
Program I	45	8,900	0	0	49	9	220
Program II	13	14,200	999	0	43	161	241
Program III	13	14,200	982	22	89	148	271
Program IV	30	10,800	412	22	76	82	280

This particular small watershed, some 50 square miles in area, is in central Nebraska; at present over 50 per cent of it is cultivated, the balance being pasture, wasteland, roads, etc. Of the cultivated land approximately one-third is usually in wheat, one-third in corn, and one-third summerfallowed. The economy of the area is based principally on wheat and corn as cash crops. The topography is a gently rolling upland breaking off to a semicanyon type of drainage.

In all four of the alternative programs listed in Table 2 the land treatment was based on land-use capabilities.

Program I included only land-treatment measures that could be established and permanently maintained with no support from structural measures. The program consisted principally of a conversion of 45 per cent of the cultivated cropland to permanent pasture, and 8900 acres of contour farming and terracing. No gradient control structures or retarding dams were considered. The annual costs were very low — $9,000. The reduction of flood damage was estimated as 49 per cent.

Program II provided for stabilizing the grades in the small watercourses so that all the land could be kept in the most intensive use commensurate with its capability (999 structures). This required only a 13 per cent conversion of cropland to permanent pasture and allowed the application of terraces and contouring on 14,200 acres. The annual costs of this program are extremely high ($161,000). Flood damage was reduced 43 per cent.

Program III was identical with Program II except that 22 retarding dams were added. Seventeen of the retarding dams were used to replace seventeen of the grade control structures. This resulted in a decrease in annual costs of $13,000 (161-148,000). It resulted in damage reduction estimated at 89 per cent. On the basis of increased flood protection and reduced costs we can, therefore, cast out Program II.

Program IV represents a reconsideration of the features of Program I and Program III, as we have dropped Program II. It is apparent that a choice must be made between the limits of a program depending on low cost and lower flood reduction (Program I) and a program of high cost and greater flood reduction (Program III).

Examining the land-treatment phases of the watershed indicated that it was possible to go to about 30 per cent conversion of cropland to permanent pasture without harmful impact on the economy of the area. This immediately resulted in a decrease in the cost of gradient control, because only the land most easily protected was left in cultivation. The 22 retarding dams would provide positive protection to irrigated lands, flood plain lands, and developments in the flood plain lands. The annual costs of Program IV would be $82,000 and the estimated damage reduction 76 per cent. Note that the net benefit (this includes increased crop yields because of conservation on the land) is the highest of any program considered.

On the basis of a practical degree of flood protection, a high net benefit, and an annual benefit of over $3 for each $1 of annual cost, Program IV appeared to be a logical program to recommend for this particular watershed of about 50 square miles in size.

I have presented in simplified terms an analysis of the program alternatives. A much more detailed analysis was made in actual procedure. For example, the benefits and costs for each type of structure were estimated, and the benefits from increased yields of crops were calculated separately from benefits from floodwater and sediment control.

These intensive studies of small watersheds within the Missouri Basin show that floodwater and sediment damages in upstream areas are serious. A rational analysis of a range of measure-combination programs can point the way to practical solutions of the problems in small watersheds.

An Electric Power Company's Responsibility in Irrigation Engineering

WHAT is the electric power company's responsibility in engineering an irrigation system? The Portland General Electric Company knows and appreciates the fact that, in the region it serves, agriculture is much more profitable with supplemental irrigation than without it, and that as a company we can be no more prosperous relatively than the community we serve. Increased income to agriculture benefits us as members of a prosperous group as well as directly from the sale of power . . .

Supplemental irrigation has played a very important part in removing certain limitations placed on agriculture. With it we are able to carry on an entirely different farm program than that practiced before.

It is with these facts in mind that we are trying to guide the farmer to avoid buying an unsound, inefficient irrigation system. We feel it is our duty to help design a system to fit the needs of our customer, one that will give him maximum plant efficiency at lowest possible operating cost.—Floyd O. Miller in *Farm Electrification* for July-August, 1950.

NEWS SECTION

SAE Tractor Meeting Program

THE national tractor meeting of the Society of Automotive Engineers will be held at the Hotel Schroeder, Milwaukee, Wis., September 12 to 14. The meeting is being sponsored in cooperation with the Milwaukee Section of SAE.

Technical papers for the program will cover earth-moving equipment, winter operation of construction equipment, relative merits of proving ground and field testing, progress in tractor tire development, standardization of parts, and discussion of the relative merits of stampings, forgings, and castings.

An important feature of the meeting will be a dinner address by Dr. Robert E. Wilson, chairman of the board, Standard Oil Company (Indiana), entitled "America's Future Oil Supplies."

The technical program for the forenoon of September 12 includes three papers, one on the use of reduced-scale models in heavy-duty equipment design by R. A. Beckwith, Koehring Co., another on earthmoving equipment design from the user's point of view by H. E. Farnam, Jr., M. A. Hanna Co., and the third on earthmoving equipment on the Minnesota iron ranges by J. H. Hearding, Jr., Oliver Iron Mining Co. The afternoon program of the same day includes three items, opening with a review of the work of the SAE Construction and Industrial Machinery Technical Committee by J. W. Bridwell, Caterpillar Tractor Co. This will be followed by a paper on winterization of construction equipment by R. W. Beal, engineer, research and development laboratories, Fort Belvoir. The concluding paper is on proving ground versus field testing by P. H. Spennetta, Caterpillar Tractor Co.

Two papers will make up the program of the forenoon session of September 13, one on the elements of metal-arc welded design by L. C. Bibber, Carnegie-Illinois Steel Co., and the other on welding design of the resistance type by F. A. Bodenheim, Federal Machine and Welder Co. The afternoon program will be opened with a joint paper by I. F. Reed, U.S. Department of Agriculture, and J. W. Shields, U.S. Rubber Co., on the effect of lug height and of rim width on the performance of farm tractor tires. The second and concluding paper of this session will be on design by measurement by W. T. Bean, Jr., a consulting engineer.

The principal feature of the program for the forenoon of September 14 is a paper on hydraulic control systems for farm tractors and implements by H. A. Ferguson, International Harvester Co. The afternoon program of the same day will open with a progress report on hydraulic cylinder standardization by E. W. Tanquary, International Harvester Co. This will be followed by a panel discussion on the subject of stampings to replace forgings and castings, which will be participated in by representatives of stamping, fabricating, and equipment companies.

The principal feature of the closing and dinner session of the meeting on the evening of September 14 will be addresses by SAE President James C. Zeder and the address by Dr. Wilson.

Pacific Coast Section Meets in January

ANNOUNCEMENT is received that the Pacific Coast Section of the American Society of Agricultural Engineers will hold its yearly meeting on January 26 and 27 in the California Fruit Growers Exchange Building, 707 West Fifth St., Los Angeles, Calif. Program for the meeting is now being planned.

It is also announced that the annual West Coast farm machinery conference, which is planned and carried out under the wing of the agricultural engineering division of the University of California at Davis, will be held at Davis, February 2 and 3.

Grassland Farming Program

THE Joint Committee on Grassland Farming is holding its 1950 meeting in conjunction with the meeting of the American Society of Agronomy and the Soil Science Society of America, at the Netherland Plaza Hotel, Cincinnati, Ohio, October 30. The chairman of the one-day meeting will be Wheeler McMillen, editor-in-chief of *Farm Journal*.

The forenoon program will open with a talk on fertilization and nutrition of grasslands by Dr. F. E. Bear, New Jersey Agricultural Experiment Station. Building soil tilth with grasslands will be discussed by G. N. Hoffer, American Potash Institute. D. F. Beard, U.S. Department of Agriculture, will talk on grass and legume mixtures essential for a grassland system. The closing talk on the program of this session will be on grassland farming management by D. Howard Doane, Doane Agricultural Service.

Four numbers will feature the afternoon program, which opens with an account of the experiences of Paul Strickler and Willis Stout, Virginia and Kentucky farmers, respectively, on their grassland programs. F. W. Duffee, University of Wisconsin, will discuss the subject of grassland mechanization. The economics of grassland farming will be discussed by Herrell DeGraff, Cornell University, and the closing number on the program will be a talk on observations from a recent grassland survey by D. R. Dodd, Ohio State University.

A.S.A.E. Meetings Calendar

October 19 and 20 — PACIFIC NORTHWEST SECTION, Commercial Hotel, Yakima, Wash.

October 20 and 21 — PENNSYLVANIA SECTION, Brunswick Hotel, Lancaster, Pa.

December 18-20 — WINTER MEETING, The Stevens, Chicago, Ill.

January 26 and 27—PACIFIC COAST SECTION, Calif. Fruit Growers Exchange Bldg., 707 W. 5th St., Los Angeles, Calif.

February 5-7 — SOUTHEAST SECTION, Peabody Hotel, Memphis, Tenn.

June 18-20 — ANNUAL MEETING, Rice Hotel, Houston, Tex.

NOTE: Information on the above meetings, including copies of programs, etc., will be sent on request to A.S.A.E., St. Joseph, Michigan

Krewatch New Washington Section Chairman

AT the last meeting of its 1949-50 meeting season, the Washington (D.C.) Section of the American Society of Agricultural Engineers chose A. V. Krewatch, extension agricultural engineer, University of Maryland, as the new chairman of the Section for the ensuing year. He succeeds H. S. Pringle, extension rural electrification specialist, Extension Service, U.S. Department of Agriculture.

Other officers elected at the meeting include the new vice-chairman, S. J. Marek, technical standards division (REA), U.S. Department of Agriculture, who served the Section this past year as secretary-treasurer. The new secretary-treasurer of the Section is Chester P. Davis, Jr., associate agricultural engineer, farm electrification division (BPISAE) USDA.

Edwards of Cornell Receives Safety Award

CARLTON M. EDWARDS, extension agricultural engineer, Cornell University, was the recipient of the Safety Award for 1950, sponsored by the ASAE Committee on Farm Safety. The award in the form of an engraved plaque, provided by the National Association of Mutual Insurance Companies, was made to Mr. Edwards and to the New York Agricultural Extension Service, by whom he is employed. Mr. Edwards' exhibit portrayed bicycle safety for rural and urban children and was displayed at the 1950 ASAE annual meeting in Washington, D. C.

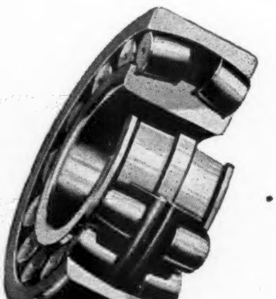
The Farm Safety Awards are made annually in three classifications on the basis of reports and demonstrations made by extension workers on farm and home fire safety and on farm and home accident safety, and on similar material submitted on farm and home fire and accident safety jointly sponsored in cooperation with other agencies. While there was only one entry in the one division of the safety award this year, R. E. Heston, a member of the Committee on Extension in charge of safety activities states that numerous letters already have been received, indicating that the 1951 activity will include entries in all three divisions. The awards are given for outstanding activity each year in extension work in farm safety to encourage extension agricultural engineers in promoting activity in safety education.

A-E Degree Offered at Colorado A. & M.

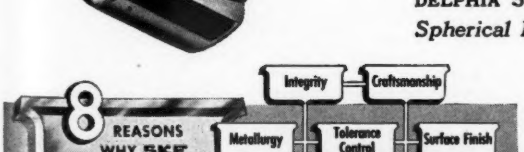
COLORADO A. & M. College joins a large group of land-grant colleges which offer a BSAE degree through a professional agricultural engineering curriculum. The new course will be administered by J. T. Strate, head, mechanical engineering division, under the dean of engineering. Due to limitation of funds and until enrollment justifies, no separate agricultural engineering division is being set up now. For the present the new agricultural engineering curriculum will be sponsored by the mechanical engineering division.

The freshman year is the same as for all engineering students. With the exception of a course in crop production, the sophomore year is identical to that given students in mechanical engineering. Besides the basic subjects in agriculture and the core of engineering courses such as thermodynamics, mechanics of materials, (*Continued on page 472*)

THAT FIELDS MAY NOT LIE FALLOW



There've been tremendous strides in agriculture since the man with the hoe tilled the fields and bent back-breakingly to the harvest. Today, this $30 billion industry is increasingly mechanized . . . produces ever-larger crops at ever-lower costs. And in these tractors, cultivators, harrows, combines, reapers, no part is more important than the bearings that mean smooth, dependable operation. Through continuous research, advanced metallurgy, manufacture to the most exacting standards of quality, and through rigid control of every operation, SKF has developed Ball and Roller Bearings that meet precisely the requirements and standards of builders of agricultural machinery . . . through long-range planning, anticipates the needs of improved and more efficient design. SKF INDUSTRIES, INC., PHILADELPHIA 32, PA., *the pioneers of the Deep Groove Ball Bearing—Spherical Roller Bearing—Self-aligning Ball Bearing.* 7029



SKF

BALL AND ROLLER BEARINGS

NEWS *(Continued from page 470)*

machine design, fluid mechanics, hydrology, etc., advanced subjects in agricultural engineering will include irrigation and drainage, farm structures, farm machinery, and farm power.

For many years the division of mechanical engineering has had a research staff working at the agricultural experiment station on agricultural mechanization. The two programs of research and teaching can now complement each other.

Louisiana Recognizes Agricultural Engineers

ACT No. 73 of the Louisiana state legislature, revising previous laws of the state on engineering registration, specifically names agricultural engineering as one of the branches to be recognized and covered by engineering registration and certificates within the state. Other branches of engineering covered by the registration law include chemical, civil, electrical, metallurgical, mining, and petroleum engineering.

British Publications on Ag Engineering

A NUMBER of publications recently received from the British Society for Research in Agricultural Engineering, the National Institute of Agricultural Engineering (Wrest Park, Silsoe, Beds, England), and the Scottish Machinery Testing Station, include abstracts on Agricultural and Horticultural Engineering (No. 1, Spring, 1950), crop drier engineering development (C S 3/1124), and reports of tests on the following: multi-planter with Ritchie easy-feed attachment, Templewood prototype 6½ cwt/hr grass meal plant, Skidmaster pneumatic tire girdle fitted to a Fordson major tractor, rick lifter, Marconi moisture meter (Type TF933), Wilmot "Alvin Blanch" grain drier, John Salmon beet harvester, Packman potato planter, Bloor farmyard manure spreaders, prototype land-rover, Claas universal seed drill, Taylor pike lifter, Slade-Curran grass drier, Letz 540 fodder chopper and silo filler, Fordson major tractor with county full tracks equipped with vaporizing oil engine, Fordson major tractor powered by Perkins P.6 engine, Massey-Harris 744D tractor (prototype), Angus single-row potato digger, I.C.I. Mark 3 drier (used as a grass drier), Salopian sweeplift crop collector, Ferguson tractor model Ted. 20 Mark II running on vaporizing oil, "Ayrshire" elevator, worn steel deep-digger shares reconditioned and modified by L. H. Tite, Esq., Causeway Green, Birmingham (multipoint shares), Scarcliffe 2-row potato planter, J.F.W. dusting unit for Colwood tractor, and Minns sugar beet harvester (Model SL2).

PSAE Publishes Journal

THE Philippine Society of Agricultural Engineers has recently issued the first number of their *Agricultural Engineering Journal*. The journal was established this year and will henceforth be published quarterly at the headquarters of the Society in Manila. The first issue contains articles on the following subjects: Performance characteristics of an alcohol-gasoline mixture (NDC-21), a substitute fuel for commercial gasoline, artificial drying of rough ice, reference points of soil moisture essential in scientific irrigation practice, agricultural land clearing, and mechanized sugar cane culture.

Credit is due the officers of the PSAE and the board of editors for a commendable job in assembling and producing this first issue. We believe that it will serve to knit together those engaged in applying engineering techniques to Philippine agriculture and foster its advancement through better understanding of the problems involved, by stimulation and direction of research to solve those problems, and by reporting the progress of this work so that it can be applied to assure continued and increased welfare for the country's agriculture.

"Who Knows—And What"

SELECTED readers have received, or shortly will receive, from The A. N. Marquis Company requests for information pertaining to their personal specialities within their occupational fields. Information submitted will be reviewed to determine suitability for inclusion in the company's new and unique reference work, *Who Knows—And What*, the second edition of which has been put into immediate compilation following the widespread acceptance of the first edition, published earlier this year.

The unique reference value of *Who Knows* stems, according to the publishers, from two major features: (1) the inclusion of only those persons having special skills or knowledge in one or more of thousands of highly specific topics judged by the editors to be subject to general reference interest, together with information on research and experience in these fields (general public or professional eminence is not a deciding factor in selections), and (2) the locator index, which refers the user by means of a simple key to the listing of any person in the book having special knowledge about any one of the subjects included in the index.

The company, which also publishes *Who's Who in America*, will welcome any suggestions from readers. Communicate directly with the company at 210 E. Ohio St., Chicago 11, Ill.

PERSONALS OF ASAE MEMBERS

Paul D. Colbenson recently resigned as instructor in agricultural engineering at the University of Tennessee, to accept appointment as appraiser-engineer for the Farm Home Administration, U.S. Department of Agriculture, in the east Tennessee area.

Robert M. Dill, who holds the rank of major in the U.S. Army, has completed the requirements for the M.S. degree in petroleum engineering at the University of Pittsburgh and is starting a one-year training course with the Gulf Oil Corp. as a part of the Army Industrial Mobilization Program.

Winfred G. Glover recently transferred from his position as an engineer in the USDA Soil Conservation Service to the Bureau of Land Management, U.S. Department of the Interior, with the title of regional engineer. In his new work he will be engaged in soil and water conservation, and he will be located at Oakland, Calif.

Murlin R. Hodgell has resigned as extension architect at Kansas State College to accept appointment on the agricultural engineering staff of the University of Illinois where he will engage in research work.

A. B. Lewis resigned recently as instructor in agricultural engineering at Lincoln University, Jefferson City, Mo., to accept a position as associate professor of agricultural engineering at the Agricultural and Technical College, Greensboro, N. C.

W. J. Liddell was recently promoted from the position of agricultural engineer to sales manager of Sunset Engineering Co., with headquarters at the home office of the company at Riverdale, New Jersey.

John T. Olsen, formerly soil conservationist and assistant chief of the Water Conservation Division, Soil Conservation Service, USDA, was recently transferred to the position of budget examiner, Division of Estimates, Bureau of the Budget. His new work will be related to projects of the U.S. Bureau of Reclamation in the 17 western states.

Gordon W. Olson recently resigned as assistant tractor testing engineer, University of Nebraska, to become assistant field testing engineer with the John Deere Dubuque Tractor Works at Dubuque, Iowa.

Eugene P. Speck has been named station engineer and assistant specialist at the Imperial Valley Field Station of the California Agricultural Experiment Station, and is located at El Centro. He was formerly instructor in farm mechanics and machinery, College of the Sequoias, Visalia, Calif.

Robert H. Witt recently resigned as an instructor in agricultural engineering, Oklahoma A. & M. College, to accept employment as an engineer in the research engineering department of Dearborn Motors Corp., Birmingham, Mich.

NEW BOOKS

Heating, Ventilating, and Air Conditioning Guide, 1950 (28th edition). Cloth, 1422 pages, 6x9 inches. Illustrated and indexed. American Society of Heating and Ventilating Engineers (New York 10, N. Y.), $7.50.

Technical data section, manufacturers catalog data section, and brief information on the organization and activities of the ASHVE. The technical data section has seven subsection groupings and 50 chapters. Substantial changes and additions to 23 chapters are indicated. These include the chapters on physiological principles, air conditioning in the prevention and treatment of disease, air contaminants, infiltration and ventilation, heating load, fuels and combustion, heating boilers, furnaces, space heaters, chimneys and draft calculations, mechanical warm air systems, hot water heating systems and piping, radiators and convectors, air duct design, fans, air heating and cooling coils, refrigeration, motors and motor controls, sound control, industrial air conditioning, drying systems, transportation air conditioning, water services, instruments and measurements, and codes and standards.

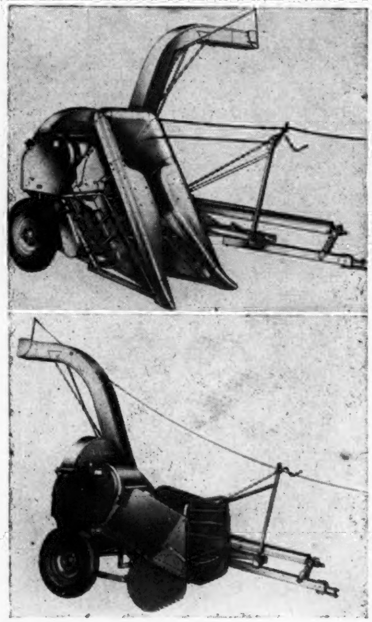
Hydrology, by Daniel W. Mead, Second edition. Cloth, xvii+728 pages, 6x9 inches. Illustrated and indexed. McGraw-Hill Book Company, Inc. (New York and London) $7.50.

This is an extensive revision of the first edition published in 1919, based on almost continuous study and accumulation of information since that time. Harold W. Mead, son of the author, Henry J. Hunt and their associates have carried on much of the later work of completing the new edition and have contributed a wealth of material from their experience as consulting engineers. Chapters cover an introduction; water — its occurrence, utilization, and control; some fundamental theories; winds and storms; hydrography; atmospheric moisture and evaporation; precipitation; rainfall measurements and records; annual rainfall in the United States and its variation; seasonal rainfall in the United States and its variation; great rainfalls; droughts; rainfall and altitude; geological agencies and their work; geology; ground waters; stream flow or runoff; variations in runoff or stream discharge; estimating runoff; floods and flood flows; the application of hydrology

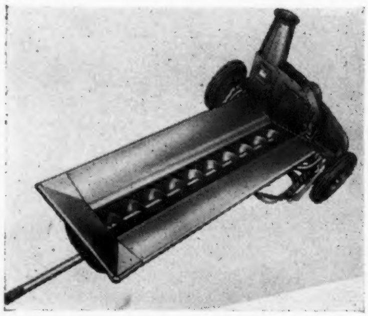
NEWS FROM ADVERTISERS

New Products and Literature Announced by AGRICULTURAL ENGINEERING Advertisers

John Deere Forage Harvester and Forage Blower. Deere & Co., Moline, Ill., announce a new dual-purpose forage harvester and forage blower, designed to cut time and costs. As a hay chopper it picks up the windrowed hay, chops it to proper length, and loads it on the wagon in a once-over job. Quickly converted to an ensilage harvester with the row-crop unit in position, it prepares standing row crops for the silo in one trip through the field. The new machine offers such time-, work-, and crop-saving features as: new stronger, non-binding feed rolls and reinforced flywheel-type cutter to handle more material in less time; non-sway delivery spout which can be changed for either silo or rear loading by simply removing two bolts and pivoting; handy clutch lever to reverse feed rolls; and common frame for flywheel cutter and stationary knife for permanent alignment, more uniform cut. The No. 50 forage blower features greater capacity and easier operation.



Two views of the John Deere forage harvester and blower used as ensilage harvester *(top)* and as hay chopper *(bottom)*



John Deere No. 50 forage blower

The longer, wider, lower receiving hopper takes fast unloading with less danger of spilling, and the exclusive combination of adjustable feed-volume doors and selective air-intake control enables the operator to maintain proper relationship of material volume to air flow for peak blowing efficiency with every crop. The positive auger-type feed and heavy-duty fan handle both green and dry materials efficiently while new retractable wheels eliminate the job of digging holes or removing the wheels when spotting. Spring-balanced hopper is easily raised for fast driving into unloading position.

(Continued on page 476)

News from Advertisers

(Continued from page 474)

Dearborn Side Delivery Rake. Dearborn Motors Corp., Detroit 3, Mich., suggests that every field is a "level field" for the new side-delivery rake now taking its place in the Dearborn line of farm equipment. A floating reel allows the new rake to follow the contour of the land, raking cleanly. Since the reel is ground-driven, no power take-off parts are required and there is no "whipping" of the crop when tractor motion is slowed down. The reel height is adjusted easily for field operation or raised for rapid transport by the tractor hydraulic control.

Dearborn side-delivery rake

The rake was originally developed for tough raking jobs in the heavy-yielding irrigated Pacific Coast region and later proved ideal for a wide variety of raking jobs. It rakes approximately an 8-foot swath and leaves the hay loose and fluffy for faster curing. With only two wheels, the new rake is highly maneuverable and turns almost as short as the tractor's own turning radius. It is designed to permit the speed which takes full advantage of good weather.

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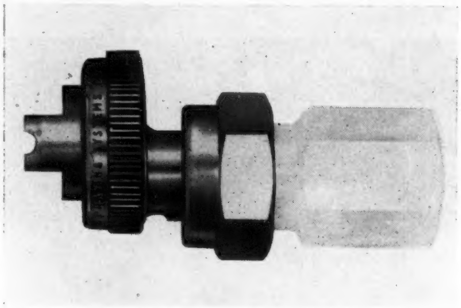
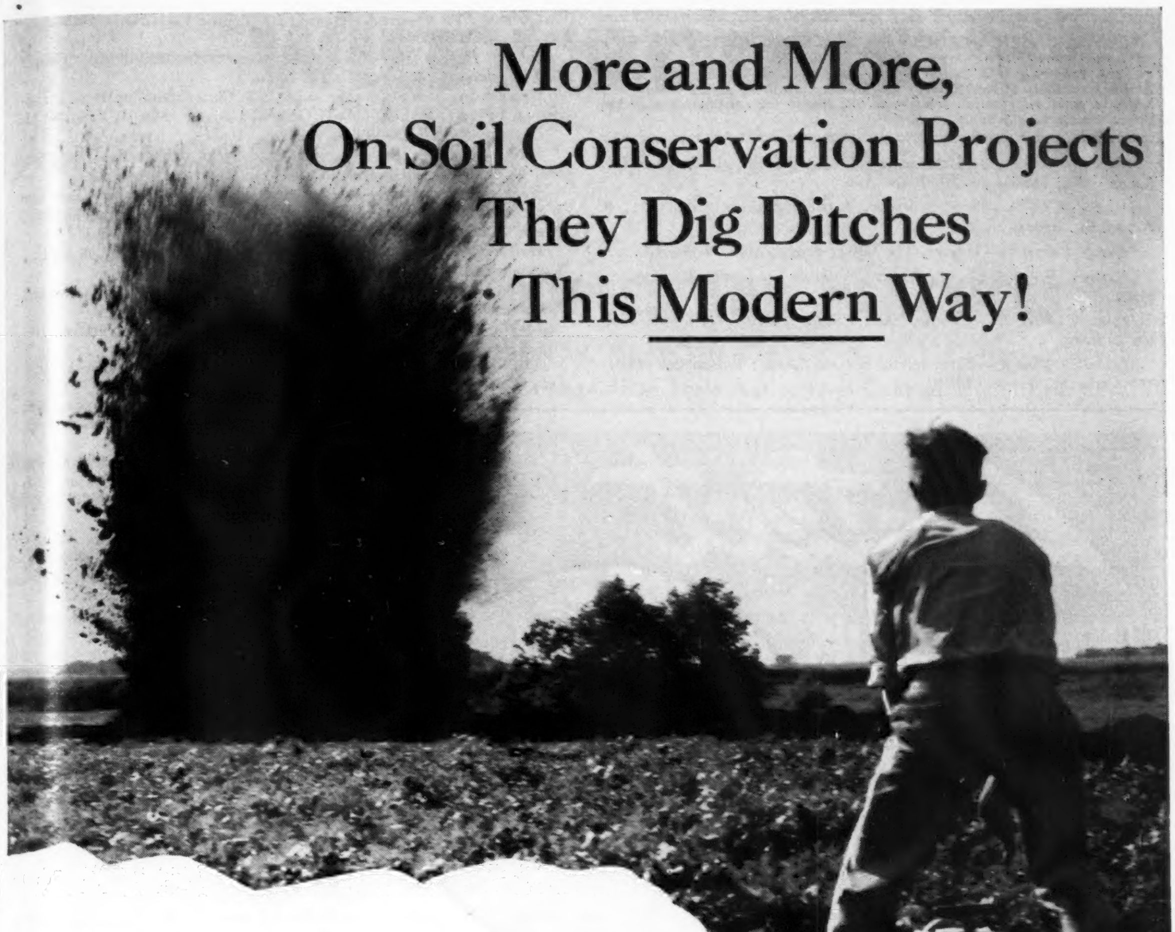
MulTeejet Combination Nozzle. Spraying Systems Co., 3226 Randolph St., Bellwood, Ill., announces a new single-turret-head MulTeejet which gives four sprays with one nozzle for insecticide spraying. The nozzle is recommended for the user of portable or hand sprayers. The tip of the nozzle is built with four different orifice openings; it can be rotated and indexed in position to give the user a choice of four different spray patterns for insecticide spraying. It is light in weight and simple to operate. The MulTeejet also fits the cap of the Trigger Teejet to give a handy assembly for various types of spraying with shut-off trigger type valve control.



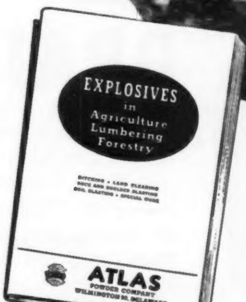
Spraying Systems combination nozzle

PROFESSIONAL DIRECTORY



Atlas explosives are important tools on soil conservation projects. They slash the time, labor, and cost involved in cutting drainage ditches . . . eliminate the need for buying or renting expensive equipment . . . take care of jobs in tough places out of reach of heavy machinery.

For up-to-the-minute dope on the use of Atlas explosives in soil conservation, send for the free Atlas book *"Explosives in Agriculture, Lumbering, and Forestry."* It explains how to select and use the right Atlas explosives for straightening meandering streams, blasting drainage ditches, removing boulders and stumps.



ATLAS EXPLOSIVES

"Everything for Blasting"

ATLAS POWDER COMPANY, Wilmington 99, Del. • *Offices in principal cities • Cable Address—Atpowco*

Applicants for Membership

The following is a list of recent applicants for membership in the American Society of Agricultural Engineers. Members of the Society are urged to send information relative to applicants for consideration of the Council prior to election.

Barnes, James D.—Field engr., Tractor Works, J. I. Case Co., Racine, Wis. (Mail) 1122½ Blake Ave.

Butler, Karl D.—Farm counselor, Avco Mfg. Corp. (Mail) 212 S. Aurora St., Ithaca, N. Y.

Camp, Robert J.—Trainee, The Oliver Corp. (Mail) Loda, Ill.

Carlson, Bernard E.—Chief engr., Superior Separator Co., Hopkins, Minn.

Flint, Charles H.—Trainee, SCS, USDA. (Mail) 1118 Elm, Harlan 2, Iowa

Gillette, Allen K.—Farm service advisor, Detroit Edison Co. (Mail) 315 Cedar St., Lapeer, Mich.

Gillette, Roy A.—Asst. des. engr., J. I. Case Co. (Mail) 3118 Summerdale Ave., Rockford, Ill.

Green, Homer H.—Des. engr., Minneapolis-Moline Co. (Mail) 4027 S. Sheridan, Minneapolis 10, Minn.

Greenwood, Bobby R.—Agr. engr., U.S. Cotton Ginning Branch Laboratory, BPISAE, USDA. (Mail) General Delivery, Mesilla Park, N. M.

Greiner, Russell D.—R. R. 1, Keota, Iowa

Hansen, Vaughn E.—Irrigation engr., SCS, USDA; and res. asst. prof. of irrigation, Utah State Agricultural College, Logan, Utah

Hebblethwaite, Peter—Asst. experimental officer, National Institute of Agricultural Engineering, Wrest Park, Silsoe, Bedfordshire, England. (Mail) N.I.A.E. Staff Club

Heifner, Keith D.—Elecn. advisor, Kankakee Valley R.E.M.C., Wanatah, Ind. (Mail) P. O. Box 6

Jacobs, Carl M.—Des. engr., The Oliver Corp. (Mail) Elliotts Tourist Court, Shelbyville, Ill.

Jones, Wayne D.—Agr. engr., Public Service Co. of Northern Illinois. (Mail) 1421½ N. Division St., Morris, Ill.

Kitching, Harold W.—Assoc. prof. of agr. eng., Ontario Agricultural College, Guelph, Ont., Canada

Kucherka, Stanley L., Jr.—Drainage engr., Fort Bend Co. Drainage District, Rosenberg, Tex. (Mail) Box 1028

Larsen, William E.—Asst. tractor testing engr., University of Nebraska, Tractor Testing Laboratory, Lincoln, Nebr. (Mail) 3230 Starr

Lewis, George G. — Sr. engr., Vickers, Inc., 1400 Oakman Blvd., Detroit, Mich.

Lien, Norman D.—Trainee, Allis-Chalmers Mfg. Co. (Mail) R. R., Platte, S. D.

Loomis, Cameron P., Jr.—Ext. agr. engr., Cornell University. (Mail) Malden-on-Hudson, N. Y.

Nelson, Oliver A. — Asst. editor, Farm Implement News. (Mail) 5824 S. Harper, Chicago 37, Ill.

Proffitt, L. M.—Des. engr., Peru Lumber Co., Peru, Nebr.

Reid, James T.—Jr. salesman, Massey-Harris Co., Atlanta Branch. (Mail) Box 491, Bremen, Ga.

Scott, Robert T.—Public relations rep., school service dept., Westinghouse Electric Corp., P. O. Box 1017, Pittsburgh 30, Pa.

Schwiesow, William F.—Agr. engr., SCS, USDA. (Mail) Box 701, Hot Springs, S. D.

Shearer, Marvin N.—Co. ext. agent, Madras, Ore.

Smith, Charles A.—R. R. 1, Cato, N. Y.

Smith, Floyd G. — Service mgr. trainee, Harold L. Ayres, Middletown, N. Y. (Mail) R. R. 2

Stephan, Frederick P.—Res. asst. in structures, elecn., Cornell University, Ithaca, N.Y. (Mail) 230 Linden Ave.

Susman, Charles D.—Agr. engr., Bureau of Reclamation, USDI. (Mail) 723 11th St., Bismarck, N. D.

Theakston, Franklyn H.—Assoc. prof. of agr. eng., Ontario Agricultural College, Guelph, Ont., Canada

Turnbull, Dale W.—Trainee, Caterpillar Tractor Co., Peoria, Ill. (Mail) 100 High, Apt. A

Wassell, Donald B. — Designer, John Deere Harvester Works, East Moline, Ill.

Watson, Eldon C.—Des. engr., Western Land Roller Co., Hastings, Nebr. (Mail) 841 N. Burlington Ave.

Wetherbe, Franklin B.—R. R. 1, Montague, Mass.

Wodnik, Frank A. — Agr. engr., SCS, USDA. (Mail) 323 W. Stanhope St., Sidney, Mont.

Zachariah, P. John—Res. asst., agr. eng. dept., Allahabad Agricultural Institute, Allahabad, India

TRANSFERS OF MEMBERSHIP GRADE

Jones, James O.—Head eng. and math. dept., University of Tennessee Junior College, Martin, Tenn. (Junior Member to Member)

Stanley, James M.—Assoc. agr. engr., BPISAE, USDA; and asst. res. prof., University of Georgia. (Mail) Coastal Plain Experiment Station, Tifton, Ga. (Junior Member to Member)

Personnel Service Bulletin

The American Society of Agricultural Engineers conducts a Personnel Service at its headquarters office in St. Joseph, Michigan, as a clearing house (not a placement bureau) for putting agricultural engineers seeking employment or change of employment in touch with possible employers of their services, and vice versa. The service is rendered without charge, and information on how to use it will be furnished by the Society. The Society does not investigate or guarantee the representations made by parties listed. This bulletin contains the active listing of "Positions Open" and "Positions Wanted" on file at the Society's office, and information on each in the form of separate mimeographed sheets, may be had on request. "Agricultural Engineer" as used in these listings, is not intended to imply any specific level of proficiency, or registration, or license as a professional engineer.

POSITIONS OPEN: (1949): AUGUST—O-34-675. NOVEMBER—O-127-690. (1950): JANUARY—O-189-692. MARCH—O-262-700, 262-701. JUNE—O-355-717, 379-718, 393-719, 395-720, 407-721. JULY—O-360-722, 396-723, 418-724, 418-725, 421-726. AUGUST—O-21-501, 21-502, 25-503, 25-504, 31-505.

POSITIONS WANTED: (1949): JULY—W-13-299. SEPTEMBER—W-67-312. OCTOBER—W-111-316. DECEMBER—W-145-323, 146-324. (1950): JANUARY—W-164-331, 175-334, 179-335, 190-338. MARCH—W-227-351, 247-352, 228-353, 256-355, 246-360, 268-361, 258-362. APRIL—W-294-368, 304-370, 291-373, 307-375. MAY—W-320-376, 327-377, 328-378, 333-380, 339-384, 349-385, 351-386. JUNE—W-348-391, 366-392, 364-393, 384-395, 383-397, 387-399, 274-400, 369-401, 378-402, 354-403, 394-404. JULY—W-400-406, 402-407, 382-408, 337-409, 398-411, 414-412, 412-413, 410-414, 417-415. AUGUST—W-5-1, 4-2, 11-3, 12-4, 26-5.

NEW POSITIONS OPEN

DESIGN ENGINEERS (several) for design and development of farm machinery in a midwestern plant. Must have technical training and a good spirit of cooperation. Available openings provide opportunities for designers in several brackets as to experience. Good opportunity for advancement. Salary open. O-34-506

NEW POSITIONS WANTED

DEVELOPMENT, extension, teaching, or research in power and machinery or soil and water, with public service or industry, anywhere in the U.S. BS deg in agriculture, 1941; BS deg in agricultural engineering, 1949, MS deg in agricultural engineering, September 1950, Michigan State College. Farm background. Farm machinery sales and service in dealer organization, 6 months. Extension work in farm machinery, 8 months. Extension work in farm safety and general agricultural engineering, 3 years. Teaching experience 6 months. Graduate assistant in research while completing work on MS deg. War enlisted service in Army Medical Corps, commissioned service in Medical Administrative Corps. Married. Age 34. No disability. Available October 1. Salary open. W-43-6

DESIGN, development, research, sales, service, or writing, in power and machinery or soil and water, with public service or industry anywhere in the U.S. Willing to travel. BS deg in agricultural engineering, 1950, Texas A.&M. College. Farm background, with general farm duties part time while in high school, 4 years, and full time 2 years, 4 months after military service. War non-commissioned service in Army Signal Corps. Married. Age 24. No disability. Available now. Salary $3000-3600. W-36-7

DESIGN, development, research, extension, or teaching in soil and water hydrology, or hydraulic engineering, anywhere in the U.S. BS deg in civil engineering, 1940, National Chiao Tung University, China. MS deg in civil engineering, major in structural engineering, Pennsylvania State College, 1948. PhD deg in engineering, major in hydraulic engineering, 1950, University of Illinois. Experience includes teaching civil engineering in Chinese colleges and universities, 1941-47. Nearly 2 years as civil engineer, Bureau of Public Works, Formosa. Research assistant while studying in the U.S. Married. Age 31. No disability. Available now. Salary $4500. W-39-8

DESIGN, development, or research in power and machinery or farm structures, in public service or industry, anywhere in the U.S., preferably West or Midwest. BS deg in engineering, agricultural option, 1950, University of California at Los Angeles. Farm background. Auto parts salesman, 5 years. Stock clerk in aircraft factory, 8 months. Radio technician 3 years in Navy. Part time research and other work while in school. War enlisted service in Navy 3 years. Married. Age 31. No disability. Available now. Salary $3000. W-38-9

DESIGN, development, research, or extension in farm structures with public service or industry, preferably in the South. BS deg in agricultural engineering, 1949, University of Georgia. MS deg in agricultural engineering, 1950, University of Illinois. Experience in research one half time while at University of Illinois, including 12 months on applications of aluminum, 6 months on dairy housing. War enlisted service in Cavalry, 2 years. Married. Age 25. No disability. Available now. Salary $3500-4200. W-40-10

EXTENSION, teaching, research, or service in power and machinery or rural electrification with public service or industry, anywhere in the U.S. Willing to travel. BS deg in agriculture, 1950, Cornell University. Farm background. Student instructor in farm shop 2½ years in agricultural engineering department. Additional part time work as student assistant in farm machinery courses. Operated generator station 4½ months in Army. One summer in building construction and maintenance. One winter and spring as machine operator in woodworking plant. Temporarily employed since graduation on a large dairy farm. War enlisted service in Infantry 3½ years. Married. Age 27. No disability. Available now. Salary open. W-48-11